EXECUTIVE SUMMARY

Introduction

T N & Associates, Inc. (TN&A) has prepared this Feasibility Study (FS) report to document field activities and analysis conducted between January 2002 and August 2003 for the Pemaco Superfund Site in Maywood, California. This work was conducted under the authority of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA, also known as "Superfund") as amended by the Superfund Amendments and Reauthorization Act (SARA) and the CERCLA regulations published in the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). TN&A conducted this work under contracts issued by the U.S. Army Corps of Engineers (USACE), Omaha District, at the request of the United States Environmental Protection Agency (USEPA), Region IX.

The FS is the CERCLA mechanism for the development, screening, and detailed evaluation of remedial action alternatives. As recommended in the NCP and USEPA guidance, the Remedial Investigation (RI) and FS were conducted concurrently for the Pemaco project. Data collected in the RI influenced the development of remedial alternatives in the FS, which in turn affected the data needs and scope of treatability studies and additional field investigations.

The identification, screening, and development of alternatives phase of the FS process began during RI scoping when likely response scenarios were first identified. The development of alternatives involved:

- Identifying remedial action objectives;
- Identifying potential treatment, resource recovery, and containment technologies that would satisfy these objectives;
- Screening the technologies based on their effectiveness, implementability, and cost;
- Assembling technologies and their associated containment or disposal requirements into alternatives for the contaminated media at the site or for the operable unit.

Site Background

The Pemaco Superfund Site is comprised of 1.4 acres located in a mixed industrial and residential neighborhood in Maywood, Los Angeles County, California. Pemaco, Inc. formally operated as a custom chemical blender during the 1950s until 1991. A wide variety of chemicals were used onsite including chlorinated and aromatic solvents, flammable liquids, oils and specialty chemicals. These chemicals were stored in drums, aboveground storage tanks and underground storage tanks. After the site was abandoned by its owner in 1991, the remaining stored chemicals, drums, ASTs, and USTs were removed by the USEPA between 1992 and 1998. Environmental assessments performed between 1990 and 1999 have identified soil and groundwater contamination that originated from the blending and storage of chemicals. A soil vapor extraction (SVE) system was installed as an interim measure in 1998 and operated until 1999, when it was shut down due to community concerns with emissions from the thermal oxidation unit used to treat the extracted vapors.

The USEPA enlisted the site into the Superfund program in 1999, and TN&A performed a full-scale Remedial Investigation (RI) between January 2001 and November 2001. TN&A conducted treatability tests from December 2001 to December 2002 to support this FS. Groundwater monitoring, "data gap" investigations, and pilot-scale activities for the evaluation of remedial technologies have been in progress for the Pemaco site since May 2001.

The City of Maywood, in conjunction with the Trust for Public Land, is planning to use the Pemaco property along with adjacent properties to build a public recreational park. This project is termed the Maywood Riverfront Park project. Future remedial activities at the Pemaco site and adjacent sites will be integrated with the existence of this park.

RI Summary

The objectives of the RI were to:

1. Define the nature and extent of contamination (chemical types, concentrations, distributions, etc.) associated with past operations at the Pemaco property;
2. Identify Federal and State applicable or relevant and appropriate requirements (ARARs) pertinent to management and remediation of the site; and
3. Conduct a baseline risk assessment to quantify potential threats that may exist to human health, relative to contamination at and from the Pemaco site.

The RI activities included extensive sampling of soil, soil vapor, indoor and outdoor air, and groundwater on the Pemaco property and surrounding area. Over 2,000 environmental samples were collected for the RI. These samples were analyzed by various analytical methods to determine site-specific physical and chemical attributes.

Contaminants of Potential Concern (COPCs)

Analytical results of the environmental samples collected during the RI indicate that chemical releases from past operations practices at the Pemaco property have impacted soil and groundwater at the site and offsite, below adjacent industrial and nearby residential properties. Fifty-six contaminants of potential concern (COPCs) have been identified based on the comparison of analytical results to State of California Maximum Contaminant Levels (MCLs) and USEPA Region IX Preliminary Remediation Goals (PRGs). COPCs include metals, solvents/non-halogenated volatile organic compounds (NHVOCs), semi-volatile organic compounds (SVOCs), and volatile organic compounds (VOCs).

A general breakdown of environmental media "zones" and the relative types and distribution of COPCs in each is outlined in the following table (next page):

Media or Zone	Number of COPCs Present	Types of COPCs	Depth	Extent
Surface and Near-surface Soil	11	SVOCs and Metals	6 inches to 2.5 ft bgs	Onsite and adjacent industrial properties
Upper Vadose Zone	21 (DAF 20)	NHVOCs, VOCs, SVOCs, and Metals	2.5 ft to 35 ft bgs	Onsite
Lower Vadose Zone	11 (DAF 1)	VOCs and Metals	35 ft to 65 ft bgs	Onsite
Perched Groundwater	32	NHVOCs, VOCs, SVOCs, and Metals	25 ft to 35 ft bgs	Mixed VOC plume to 200 ft to southwest of site
Exposition Groundwater Zones*	20	NHVOCs, VOCs, and Metals (Metals are likely background levels)	65 ft to 100 ft bgs	VOC plume (primarily trichloroethene) extends ~1100 ft to southwest of site

bgs = below ground surface
DAF = dilution attenuation factor for soil screening levels for the threat to groundwater
* The Exposition Groundwater Zones include five distinct saturated zones present between 65 and 175 ft bgs that are stratigraphically connected to the more regional Exposition Aquifer. Because these groundwater zones do not comprise a viable aquifer in the vicinity of the Site, they have been informally labeled Exposition Zones 'A' through 'E'.

It should be noted that while ambient air is a media with known COPCs (VOCs) in the vicinity of the Pemaco site, data indicates that many of the VOCs found in breathing zone air could be due to background conditions of the Los Angeles basin. COPCs in soil vapor (VOCs) will be addressed through remediation of subsurface soils and groundwater.

Risk Assessment

A baseline risk assessment was performed to quantify potential risks to human health that may be caused by chemicals in soil and groundwater identified during RI activities at and adjacent to the Pemaco site. Five models of human exposure consisting of: (1) a current trespasser model, (2) a future park user model, (3) a future excavation worker model, (4) a future onsite residential exposure model, and (5) a current offsite residential model were considered based on current, proposed, and possible future land uses. The models determine what concentration of a hazardous substance in an environmental medium would result in the maximum potential intake that is not expected to have an adverse impact upon human health. These intake levels were established based either on an acceptable incremental cancer risk for potential carcinogens or on an intake level that is within acceptable levels for noncarcinogens.

Generally accepted USEPA screening levels for carcinogenic health risks are between10^{-4} and 10^{-6} and for non-carcinogenic health risks a hazard quotient less than 1.0 is considered to be acceptable. A summary of the total carcinogenic risks and total non-carcinogenic hazards for each receptor scenario calculated as part of the Pemaco risk assessment is tabulated below (next page). The specific chemical risk drivers associated with each media are discussed in the paragraphs following the table.

Receptor	Media	Total Carcinogenic Risk		Total Noncarcinogenic Hazard Quotient	
		RME (1)	CT (2)	RME(1)	CT(2)
Current Onsite					
Trespasser	Surface soil	4.5E-06	4.3E-07	1.0E-02	2.2E-03
Future Onsite					
Park User	Surface soil	7.9E-05	1.9E-05	3.1E-01	1.2E-01
Excavation Worker	Surface and subsurface soil	6.9E-06	8.5E-07	1.2E-01	2.5E-02
Resident	Surface soil, groundwater and vapor intrusion	1.6E-01	4.5E-02	1.8E+03	7.5E+02
Current Offsite					
Resident	Indoor and Outdoor air	9.2E-05	2.3E-05	1.1E+01	7.1E+00
	Outdoor air background	3.7E-05	NA	4.4E+00	NA
	Modeled vapor intrusion	1.6E-05	3.1E-6	1.0E-02	5.5E-03

(1) Reasonable maximum exposure parameters

(2) Central tendency exposure parameters

Under current land-use conditions, when the only site use is by occasional trespassers, the estimated carcinogenic risks using RME parameters falls at the lower end of the USEPA target risk range of 10^{-4} and 10^{-6}. The carcinogenic risk was primarily due to potential exposure to benzo(a)pyrene and dibenzo(a,h)anthracene by ingestion and dermal exposure routes. Using CT parameters, the carcinogenic risk for the Trespasser was below the target range. The total noncarcinogenic hazard index was well below the target level of 1.0.

The estimated carcinogenic risks using the future park user scenario with either the RME or CT parameters falls in the middle of the USEPA target risk range. The carcinogenic risk was primarily due to potential exposure to benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene by ingestion and dermal exposure routes. The total noncarcinogenic hazard index was well below the target level of 1.0.

The estimated carcinogenic risks using the future excavation worker scenario with RME parameters falls in the lower end of the USEPA target risk range and falls below the target range using CT parameters. The carcinogenic risk was primarily due to potential exposure to arsenic, benzo(a)pyrene, and dibenzo(a,h)anthracene by the ingestion exposure route. The total noncarcinogenic hazard index was well below the target level of 1.0.

The estimated carcinogenic risks using the future onsite resident exposure scenario, with either RME or CT parameters, falls well above the upper end of the USEPA target risk range. The estimated carcinogenic risks were primarily due to exposure to contaminants in the Exposition groundwater zones. The estimated carcinogenic risks were greatest for inhalation exposure, but also exceeded the upper end of the USEPA target risk range due to ingestion and dermal exposure. The carcinogenic risk was primarily due to potential exposure to arsenic, benzene, chloroform, TCE, and vinyl chloride. The total noncarcinogenic hazard index also greatly exceeded the target level of 1.0. The elevated noncarcinogenic hazard index was primarily due to potential exposure to acetone, arsenic, benzene, chloroform, cis-1,2-dichloroethene, manganese, TCE, and vinyl chloride.

The estimated carcinogenic risks based on measured indoor and outdoor air concentrations, using the current offsite resident exposure scenario falls within the target risk range using either RME or CT exposure parameters. The carcinogenic risk was primarily due to potential exposure to chloroform, benzene, methyl tert-butyl ether, and tetrachloroethene. The total noncarcinogenic hazard index also exceeded the target level of 1.0 with either RME or CT parameters. The elevated noncarcinogenic hazard index was primarily due to potential exposure to chloroform, 1,2,4-trimethylbenzene, and benzene. Risk estimates, based on background air sample data, also resulted in carcinogenic estimates within the USEPA target risk range and the noncarcinogenic hazard quotient also exceeded the target level of 1.0 using RME parameters. Thus, the site-related risks may lie within the level of background risk, but more background data is needed to establish an adequate statistical basis for comparison.

Estimates of carcinogenic risk based on vapor intrusion modeling from maximum observed shallow soil gas concentrations also gave estimates of cancer risk within the USEPA target range, but the noncancer hazard estimate was well below the threshold level of 1.0. The greatest potential cancer risk was due to exposure to trichloroethene. The indoor air vapor intrusion pathway is of minimal concern at the Pemaco site, based on the results of the Johnson-Ettinger model (USEPA, 2000c).

Risk-based values, or remediation goal options, were developed for each receptor risk driver summarized above as part of the risk assessment. These goals were calculated to determine concentrations that will result in target hazard indexes of 1.0 or target cancer risk of 10^{-6}. The remediation goal options were then used in the development of remedial action objectives.

Feasibility Study

Remedial Action Objectives

TN&A developed remedial action objectives (RAOs) for Pemaco that specify the environmental media and risk drivers/contaminants of concern (COCs) at the site, exposure routes and potential receptors of these COCs, and preliminary remediation goals to reduce contamination and/or reduce receptor exposure.

RAOs for Pemaco are summarized in the following table (next page).

Environmental Media	Remedial Action Objectives
Surface and Near-Surface Soils	▪ Prevent risk of human exposure (residents, park users, future construction workers) by direct contact (via inhalation, ingestion, or dermal contact) with soils having (1) carcinogenic COCs in excess of ARARs/TBCs, (2) a total excess cancer risk for all contaminants of greater than 10E-4 to 10E-6 and, (3) a non-carcinogenic threshold value greater than 1.0. ▪ Prevent migration of COCs to the perched groundwater at a rate that would cause groundwater to exceed ARARs/TBCs*.
Upper Vadose Zone Soil	▪ Prevent risk of human exposure (future construction workers) by direct contact (via inhalation, ingestion, or dermal contact) with soils having (1) carcinogenic COCs in excess of ARARs/TBCs, (2) a total excess cancer risk for all contaminants of greater than 10E-4 to 10E-6 and, (3) a non-carcinogenic threshold value greater than 1.0. ▪ Prevent migration of COCs to the perched groundwater at a rate that would cause groundwater to exceed ARARs/TBCs. ▪ Prevent further offsite migration of COCs onto adjacent properties.
Perched Groundwater	▪ Prevent risk of residential human exposure by direct contact (via inhalation (steam), ingestion, or dermal contact) with groundwater having (1) carcinogenic COCs in excess of ARARs/TBCs, (2) a total excess cancer risk for all contaminants of greater than 10E-4 to 10E-6 and, (3) a non-carcinogenic threshold value greater than 1.0. ▪ Prevent further offsite migration of COCs onto adjacent properties. ▪ Prevent migration of COCs to the Exposition groundwater zones at rates that would cause groundwater to exceed ARARs/TBCs. ▪ Restore groundwater quality in perched groundwater zone to ARARs/TBCs or to local background groundwater quality.
Lower Vadose Zone Soil	▪ Prevent migration of COCs to the Exposition groundwater zones at rates that would cause groundwater to exceed ARARs/TBCs.
Exposition Groundwater Zones	▪ Prevent risk of residential human exposure by direct contact (via inhalation (steam), ingestion, or dermal contact) with groundwater having (1) carcinogenic COCs in excess of ARARs/TBCs, (2) a total excess cancer risk for all contaminants of greater than 10E-4 to 10E-6 and, (3) a non-carcinogenic threshold value greater than 1.0. ▪ Minimize further migration of COCs. ▪ Prevent migration of COCs to local production wells. ▪ Prevent migration of COCs to deeper Exposition groundwater zones at rates that would cause groundwater to exceed ARARs/TBCs in those zones. ▪ Restore groundwater quality in Exposition Zones ‘A’ and ‘B’ to ARARs/TBCs or to local background groundwater quality.

* For those chemicals lacking ARARs, other criteria to be considered (TBCs) were used, primarily the USEPA Region IX Preliminary Remediation Goals (PRGs).

Identification and Screening of Technologies and Process Options

Potentially applicable remedial technologies were identified to address each of five media zones as well as extracted groundwater and extracted vapor (*ex-situ* treatment technologies). Potentially applicable technologies/process options were then screened by media zone, as follows:

Media Zone	Number of Potentially-Applicable Technologies Identified and Screened	Number of Process Options Identified and Screened	Number of Process Options Retained
Surface and Near-Surface Soil	16	36	10
Upper Vadose Zone Soil	16	38	10
Perched Groundwater	20	62	9
Lower Vadose Zone Soil	9	26	7
Exposition Groundwater Zones	20	62	9
Extracted Groundwater	6	30	6
Extracted Vapor	4	9	3

All of the remedial technologies and process options were screened and evaluated based on technical implementability, effectiveness, and cost.

Basis for Development of Remedial Alternatives
It was determined that the interrelationship between the five media zones (i.e., (1) surface and near-surface soils, (2) the upper vadose zone soils, (3) the perched groundwater, (4) the lower vadose zone soils, and (5) the Exposition groundwater zones) is not significant enough to warrant developing one set of remedial alternatives for the entire site. In fact, the features of the five media zones are very distinct. Therefore, TN&A developed an approach that identified combinations of media zones and treatment technologies for groundwater and soil that are compatible and provide a degree of economic or other benefit when used in conjunction with each other. This approach resulted in development of the organizing concept of three "remediation zones" consisting of:

- Surface and Near-Surface Soil Remediation Zone (0-3 ft bgs),
- Upper Vadose Soil and Perched Groundwater Remediation Zone (3-35 ft bgs), and
- Lower Vadose Soil and Exposition Groundwater Remediation Zone (35-100 ft bgs).

Identification and Screening of Remedial Alternatives
Based on the remedial action objectives, quantity and composition of media to be treated, key assumptions, and technical project meetings, the most promising technologies and process options (retained from the screening of technologies phase of the FS) were assembled into remedial alternatives for each remediation zone.

Remedial alternatives assembled for the two upper remediation zones (surface/near-surface soil remediation zone and the upper vadose zone soil and perched groundwater remediation zone) typically utilize one to two remedial technologies to address the entire area of contamination, as contaminant concentrations are relatively homogenous within these zones. Remedial alternatives assembled for the lower vadose zone soil and Exposition groundwater remediation zone typically include multiple remedial technologies, as this zone has clearly delineated areas with varying degrees of contamination (i.e., 10,000 µg/L-contour, 1,000 µg/L-contour, 100 µg/L-contour, and 10 µg/L-contour of the composite Exposition 'A' and 'B' Zone TCE plume). These plume contours were used to define the application of suitable remedial technologies based on volume and contaminant concentration to assemble an effective remedial alternative for this zone.

Once an appropriate range of waste management options was developed for each remediation zone, the remedial alternatives were screened based on effectiveness, implementability, and cost. Remedial alternatives that were retained during this initial screening process were analyzed more fully in the detailed evaluation phase of the FS.

The assembled remedial alternatives retained for each remediation zone are outlined below.

Surface and Near-surface Soil (0 to 3 ft bgs) Remediation Zone Alternatives

- No Action
- Soil Cover/Revegetation
- Excavation/Offsite Disposal

Upper Vadose Soil and Perched Groundwater (3 to 35 ft bgs) Remediation Zone Alternatives

- No Action
- High-Vacuum Dual-Phase Extraction/Ultraviolet Oxidation/Flameless Thermal Oxidation (FTO)/Granular Activated Carbon (GAC)
- High-Vacuum Dual-Phase Extraction/Ultraviolet Oxidation/GAC
- *In-situ* Chemical Oxidation
- Enhanced *In-situ* Bioremediation
- Monitored Natural Attenuation

Lower Vadose Soil and Exposition Groundwater (35 to 100 ft bgs) Remediation Zone Alternatives

- No Action
- *In-situ* Chemical Oxidation/*In-situ* Chemical Reduction/Groundwater Pump and Treat/Monitored Natural Attenuation/Ultraviolet Oxidation
- Enhanced *In-situ* Bioremediation/Groundwater Pump and Treat/Monitored Natural Attenuation/Ultraviolet Oxidation
- Vacuum-Enhanced Groundwater Extraction/Groundwater Pump and Treat/Monitored Natural Attenuation/Ultraviolet Oxidation/FTO/GAC
- Vacuum-Enhanced Groundwater Extraction/Groundwater Pump and Treat/Monitored Natural Attenuation/Ultraviolet Oxidation/GAC
- Electrical Resistance Heating with Vapor Extraction/Vacuum-Enhanced Groundwater Extraction/Groundwater Pump and Treat/Monitored Natural Attenuation/Ultraviolet Oxidation/FTO/GAC
- Electrical Resistance Heating with Vapor Extraction/Vacuum-Enhanced Groundwater Extraction/Groundwater Pump and Treat /Monitored Natural Attenuation/Ultraviolet Oxidation/GAC

Detailed Evaluation of Remedial Alternatives

Detailed evaluations of the above alternatives were completed to further assess their applicability to the site. The remedial alternatives were evaluated individually against nine evaluation criteria that the USEPA has developed to address the statutory requirements and preferences of CERCLA as amended by SARA and the regulations published in the NCP.

The nine evaluation criteria are:

- Overall protection of human health and the environment;
- Compliance with ARARs;
- Long-term effectiveness and permanence;
- Reduction of toxicity, mobility, or volume;
- Short-term effectiveness;
- Implementability;
- Cost;
- State acceptance; and
- Community acceptance.

Through evaluating each remedial alternative against the nine criteria, alternatives that would not meet the requirements under the NCP for an appropriate remedy were eliminated. The alternatives were then compared (comparative analysis) against one another to determine their respective strengths and weaknesses and to identify the key trade-offs that must be balanced for the Site. The results of the comparative analysis are summarized below so that an appropriate remedy consistent with the NCP can be selected.

Comparative Analysis of Alternatives

The remedial alternatives developed for each of the three remediation zones defined at the Pemaco site were evaluated by comparison to each other to identify relative advantages and disadvantages. The comparative analysis was based on the nine evaluation criteria specified in the NCP. *For each remediation zone, the No Action alternatives were included as a baseline for comparison as required in the NCP. The No Action Alternatives are not discussed below; however, since they do not meet the two threshold criteria, overall protection of human health and the environment and compliance with ARARs/TBCs.*

<u>Surface and Near-Surface Soil Remediation Zone</u>

The following five remedial alternatives developed for the surface and near-surface remediation zone were compared against each other using the evaluation criteria:

- N1 – No Action
- N2 – Soil Cover/Revegetation
- N3 – Excavation and Offsite Disposal

All of the remedial alternatives would be protective of human health and the environment and all would be expected to meet ARARs/TBCs.

Relative to long-term effectiveness and permanence, Alternative N2 was judged effective, but reliant on maintenance for long-term effectiveness and permanence. Alternative N3 was judged more permanent.

Alternative N3 would reduce the TMV of surface and near-surface soils at the Site. Alternative N2 would provide significant reductions in contaminant mobility thereby eliminating potential exposure routes. The COCs in this remediation zone are relatively immobile (metals and SVOCs) and reduction of TMV is not weighed as a benefit as much as for other remediation zones.

Relative to short-term effectiveness, Alternative N2 would require less time to implement and have the least effect on the local community in terms of dust, noise, and traffic.

Alternative N3 would generate more short-term effects on the local community because of the excavation and hauling operations.

All of the remedial alternatives would be readily implementable with conventional construction equipment and methods.

In terms of estimated cost, Alternative N2 has the lowest estimated capital cost and the lowest present worth (30 years of O&M were assumed). Alternative N3 would have no O&M costs, but has capital costs that are 3 to 4 times that of Alternative N2.

Upper Vadose Soil and Perched Groundwater Remediation Zone

The following six alternatives developed for the Upper Vadose Soil and Perched Groundwater Remediation Zone were compared against each other:

- SP1 – No Action
- SP2a – High-Vacuum Dual-Phase Extraction/Ultraviolet Oxidation/FTO/GAC
- SP2b – High-Vacuum Dual-Phase Extraction/Ultraviolet Oxidation/GAC
- SP3 – *In-Situ* Chemical Oxidation
- SP4 – Enhanced *In-Situ* Bioremediation
- SP5 – Monitored Natural Attenuation

All of the remedial alternatives would likely be protective of human health and the environment and all would be expected to meet ARARs/TBCs (with exception to No Action).

Relative to long-term effectiveness and permanence, the alternatives can be divided into alternatives that address both soil and groundwater (Alternatives SP2a and SP2b) and alternatives that address just groundwater (Alternatives SP3, SP4, and SP5). In the comparative analysis, the alternatives that actively address both soil and groundwater (Alternatives SP2a and SP2b, the HVDPE alternatives) were considered more favorable because they would be more effective in mitigating the long-term risks.

With exception to Alternatives SP1 (No Action) and SP5 (Monitored Natural Attenuation), all of the remedial alternatives would achieve reduction of TMV through treatment. However, only Alternatives SP2a and SP2b would reduce TMV in both soil and groundwater media. The alternatives that would involve *in-situ* treatment by chemical oxidation (Alternative SP3) and enhanced *in-situ* bioremediation (Alternative SP4) would address COCs in groundwater only (i.e., the TMV of COCs in upper vadose soil would not be reduced).

Relative to short-term effectiveness, Alternatives SP2a and SP2b are judged to be capable of achieving the remedial objectives in the shortest time. In terms of short-term effects during construction, Alternatives SP2a and SP2b would involve the most impact in the form of dust, noise, and traffic. The other remedial alternatives (*in-situ* alternatives, monitored natural attenuation) have similar, relatively minor short-term effects consistent with onsite well construction and worker safety.

All remedial alternatives would be implementable using conventional construction methods, personnel, and equipment.

In terms of estimated cost, the high-vacuum dual-phase extraction alternatives (Alternatives SP2a and SP2b), which address both upper vadose soil and groundwater, have the highest present worth values. The monitored natural attenuation alternative (Alternatives SP5) and the *in-situ* treatment alternatives (Alternative SG2 and SG3) have lower present worth values; but only address treatment of COCs in groundwater.

Lower Vadose Soil and Exposition Groundwater Remediation Zone

The following seven alternatives were developed for the Lower Vadose Soil and Exposition Groundwater Remediation Zone:

- SG1 – No Action
- SG2 – *In-situ* Chemical Oxidation/*In-situ* Chemical Reduction/Groundwater Pump and Treat/Monitored Natural Attenuation/Ultraviolet Oxidation
- SG3 – Enhanced *In-situ* Bioremediation/Groundwater Pump and Treat/Monitored Natural Attenuation/Ultraviolet Oxidation
- SG4a – Vacuum-Enhanced Groundwater Extraction/Groundwater Pump and Treat/Monitored Natural Attenuation/Ultraviolet Oxidation/FTO/GAC
- SG4b – Vacuum-Enhanced Groundwater Extraction/Groundwater Pump and Treat/Monitored Natural Attenuation/Ultraviolet Oxidation/GAC
- SG5a – Electrical Resistance Heating with Vapor Extraction/Vacuum-Enhanced Groundwater Extraction/Groundwater Pump and Treat/ Monitored Natural Attenuation/Ultraviolet Oxidation/ FTO/GAC
- SG5b – Electrical Resistance Heating with Vapor Extraction/Vacuum-Enhanced Groundwater Extraction/Groundwater Pump and Treat/ Monitored Natural Attenuation/Ultraviolet Oxidation/GAC

All of the Lower Vadose Soil and Exposition Groundwater Remediation Zone alternatives would likely be protective of human health and the environment and all would be expected to meet ARARs/TBCs (with exception to No Action).

Relative to long-term effectiveness and permanence, Alternatives SG4a, SG4b, SG5a, and SG5b are the only alternatives that would address COCs in both media (lower vadose soil and Exposition groundwater). All of these alternatives would use physical treatment to achieve a high degree of permanence in mitigating risks from COCs. The other remedial alternatives (Alternatives SG2 and SG3) would apply *in-situ* chemical/biological treatment that would be effective on COCs in groundwater only.

All of the remedial alternatives for this remediation zone would use treatment to reduce TMV of COCs in groundwater. Alternatives SG4a and SG4b (vacuum-enhanced groundwater extraction alternatives) would use treatment to reduce TMV of COCs in coarse-grained lower vadose soil, in addition to groundwater. Only Alternatives SG5a and SG5b would use treatment to reduce TMV of COCs in both coarse-grained and fine-grained lower vadose soil (in addition to groundwater).

Relative to short-term effectiveness, Alternatives SG5a and SG5b would be expected to achieve remedial action goals in the shortest time, the *in-situ* alternatives (Alternatives SG2 and SG3) being comparable. All of the alternatives have comparable and typical short-term effects during implementation.

All of the remedial alternatives would be readily implementable with conventional construction methods, personnel, and equipment. Alternatives SG5a and SG5b (electrical resistance heating alternatives) would involve specialized technology and additional site access restrictions.

In terms of estimated cost, the electrical resistance heating alternatives (Alternatives SG5a and SG5b) that would address both fine- and coarse-grained lower vadose soil and Exposition groundwater have the highest present worth values. The vacuum-enhanced alternatives (Alternatives SG4a and SG4b) have intermediate direct capital costs and present worth values, but these alternatives only address coarse-grained lower vadose soil and Exposition groundwater. Likewise, the *in-situ* treatment alternatives (Alternative SG2 and SG3) have the lowest present worth values; but only address treatment of COCs in groundwater.

TABLE OF CONTENTS

TABLE OF CONTENTS, Cont.,

TABLE OF CONTENTS, Cont.,

TABLE OF CONTENTS, Cont.,

TABLE OF CONTENTS, Cont.,

FIGURES (Volume II)

FIGURES (Volume II) Cont.,

TABLES (Volume III)

TABLES (Volume III) Cont.,

TABLES (Volume III) Cont.,

TABLES (Volume III) Cont.,

GRAPHS (Volume III)

APPENDICES (Volume III)

ACRONYMS

ALT	Active Leak Testing, Inc.
ARAR	Applicable or Relevant and Appropriate Requirements
AST	Aboveground storage tank
ASTM	American Society for Testing and Materials
bgs	Below ground surface
BTEX	Benzene, Toluene, Ethylbenzene, and Xylene
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CERCLIS	Comprehensive Environmental Response, Compensation and Liability Information System
CET	CET Environmental Services, Inc.
CLP	Contract laboratory program
CLPAS	Contract Laboratory Program Analytical Services
COC	Contaminants/chemicals of concern
COPC	Chemicals of potential concern
CPT	Cone Penetrometer Test
CSM	Conceptual site model
DCA	Dichloroethane
DCE	Dichloroethene
DNAPL	Dense non-aqueous phase liquid
DOT	Department of Transportation
DPT	Direct push technology
DRE	Destruction and removal efficiency
DQI	Data Quality Indicator
DQO	Data Quality Objective
DTSC	Department of Toxic Substances Control
E&E	Ecology & Environment
ESI	Expanded Site Investigation
FASP	Field Analytical Support Program
FHP	Free hydrocarbon product
FID	Flame ionization detector
FT	Foot or Feet
GC/MS	Gas chromatograph/mass spectrometer
HRS	Hazardous ranking system
HVDPE	High-vacuum dual-phase extraction
HVOC	Halogenated volatile organic compound
ICS	Interference check samples
IDW	Investigation-derived waste
IS	Internal Standards
LCS	Laboratory control sample
LAJR	Los Angeles Junction Railway
LQG	Large quantity generator
LUST	Leaking underground storage tank
MDL	Method detection limit
MEK	Methyl Ethyl Ketone
MIBK	Methyl Isobutyl Ketone
MIP	Membrane interface probe
MRP	Maywood Riverfront Park
MS	Matrix spike

ACRONYMS (CONTINUED)

MSD	Matrix spike duplicate
MSL	Mean sea level
MTBE	Methyl tert-Butyl Ether
NIST	National institute of standards and testing
NCR	Non-conformance report
ND	Non-detect (not detected)
NHVOC	Non-halogenated volatile organic compound
NPL	National Priorities List
NSB	Near-surface soil boring
NTU	Nephelometric turbidity unit
OERR	Office of Emergency and Remedial Response
PA/SI	Preliminary assessment/site investigation
PCB	Polychlorinated biphenyl
PCE	Tetrachloroethene
PE	Performance evaluation
PICs	Products of incomplete combustion
PID	Photoionization detector
PM	Project Manager
ppm	Parts per million
PPE	Personal protective equipment
ppb	Parts per billion
PRG	Preliminary remediation goal
PRT	Post run tubing
PSSRGs	Preliminary site-specific remediation goals
PVC	Polyvinyl chloride
QA	Quality assurance
QA/QC	Quality assurance/quality control
QC	Quality control
RAP	Regional analytical program
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
RL	Reporting limit
ROD	Record of decision
RPD	Relative percent difference
RSCC	Regional Sample Control Coordinator (or Center)
RSD	Relative standard deviation
RWQCB	Regional Water Quality Control Board
SAP	Sampling and analysis plan
SC	Sample Coordinator
SOP	Standard operating practice
SRM	Standard Reference Materials
SSHO	Site safety and health officer
SSHP	Site safety and health plan
SSB	Subsurface soil boring
SSL	Soil screening level
START	Superfund technical assistance and removal team
SVE	Soil vapor extraction
SVOC	Semi-volatile organic compound

ACRONYMS (CONTINUED)

TCA	Trichloroethane
TCE	Trichloroethene
TCL	Target Compound List
TN&A	T N & Associates, Inc.
TOC	Total organic carbon
TPH	Total petroleum hydrocarbons
TRPH	Total recoverable petroleum hydrocarbons
USACE	United States Army Corps of Engineers – Omaha District
USEPA	United State Environmental Protection Agency
UST	Underground storage tank
VE	Vapor Extraction
VOA	Volatile organic analysis
VOC	Volatile organic compound

1.0 INTRODUCTION

1.1 Purpose of Report

This Feasibility Study (FS) was prepared for the United States Environmental Protection Agency (USEPA) by T N & Associates, Inc. (TN&A) to document remedial alternatives for the Pemaco Superfund Site located in Maywood, California. This FS is based on the Remedial Investigation (RI) report (TN&A, 2002a) which satisfies the requirements set forth in the USEPA RI/FS procedures for the National Priorities List (NPL) sites.

This FS report assesses remedial alternatives for the following media (in order of depth below the surface):

- Surface and Near-surface Soil
- Upper Vadose Zone Soil
- Perched Groundwater
- Lower Vadose Zone Soil
- Exposition Zones Groundwater

This report follows the USEPA guidance for conducting an RI/FS under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (USEPA, 1988). The RI/FS guidance for preparing an FS identifies nine steps:

- Develop remedial action objectives (RAOs)
- Develop general response actions
- Identify volumes or areas of media to which response actions might be applied
- Identify and screen technologies
- Identify and evaluate technology process options
- Assemble selected representative processes into alternatives
- Evaluate the alternatives
- Assess the remaining alternatives
- Compare and evaluate the final alternatives.

Technical contacts for the Pemaco Superfund Site are:

Contact	Affiliation	Telephone
Ms. Rose Marie Caraway	USEPA, Project Manager	(415) 972-3158
Mr. John Hartley	USACE, Technical Manager	(402) 293-2523
Mr. Tim Garvey	TN&A, Project Manager	(805) 585-6386

USEPA, Region IX issued an Inter-agency agreement to the U.S. Army Corps of Engineers (USACE) Omaha District. Work in support of this FS was accomplished under Contract No. DACA45-97-D-0015, Delivery Order Contract Nos. DACA45-97-D-0015, Delivery Order 17 and DACW45-01-D-0007, Delivery Orders 01 and 02, issued to TN&A by USACE.

1.2 Organization of the Report

This report is divided into five major sections plus six appendices, which address each of the nine steps in the USEPA RI/FS guidance. A brief overview of these sections is tabulated below.

Executive Summary:	Provides an overview of the FS and recommends an alternative.
Section 1:	Presents an introduction and a summary of the RI findings. Also describes the organization of the report.
Section 2:	Defines the RAOs, the potential applicable or relevant and appropriate requirements (ARARs), the general response actions, the volumes or areas affected, and identifies and screens remedial technologies and process options.
Section 3:	Discusses development and screening of remedial alternatives. Also presents conceptual designs of alternatives retained for detailed evaluation and comparative analysis.
Section 4:	Evaluates selected alternatives and makes a comparative analysis between them.
Section 5:	References.

1.3 General Nomenclature of Environmental Media

The following nomenclature was used to describe the site subsurface in this document for purposes of describing the various zones and planned investigation activities. The terms used and a brief description of each follows:

- **Surface soil** – Soil occurring at the surface to a depth of 6 inches below ground surface (bgs).
- **Near-surface soil** – Soil occurring between depths of 6 inches and 2.5 ft bgs.
- **“Upper” vadose zone soil** – Soil between 2.5 ft bgs and the top of the fine-grained interval that occurs near 35 ft bgs (based on boring logs).
- **Perched groundwater** – The saturated zone that is present above the fine-grained unit (at 35 ft bgs). The perched groundwater zone generally occurs between 25 ft and 35 ft bgs, though the depth to water varies based on seasonal rainfall amounts.
- **Perching clay** – Clay/silt lithosome that occurs between the depths of 28 ft to 40 ft bgs. The perching clay serves as an aquitard that slows the infiltration of groundwater, which forms the perched groundwater zone.
- **“Lower” vadose zone soil** – The interval between the base of the perched groundwater (approximately 35 ft bgs) and the top of underlying saturated zone (approximately 65 ft bgs).

- **Lakewood Formation** –For purposes of this investigation, the Lakewood Formation boundaries will include those strata and lithosomes between 35 ft bgs (top of fine-grained unit) and 200 ft bgs.

- **Lakewood Formation Aquifers and Groundwater Zones** – Regional aquifers within the Lakewood Formation include the Exposition Aquifer and the Gage/Gardena Aquifer. Based on regional data, the Exposition Aquifer is present at depths between 80 ft and 200 ft bgs. The Exposition Aquifer, within the study area, is not a viable aquifer, because the groundwater yield does not produce economically significant quantities of water to local production wells. However, there are five distinct saturated zones present between 65 and 180 feet beneath the site and surrounding area that are stratigraphically equivalent with the more regional Exposition Aquifer. These zones are identified as Exposition Zones ‘A’ through ‘E’ for the purposes of this project. The presence of the Gage/Gardena Aquifer has not been confirmed beneath the site, but is assumed to exist between 180 and 200 feet bgs. The Exposition ‘E’ Zone referenced above may be part of the Gage/Gardena Aquifer, but for the purposes of this report all saturated zones between 65 and 180 feet bgs will be referred to as Exposition Zones.

- **San Pedro Formation** – For this investigation, the top of the San Pedro Formation will be placed at the base of the Gage/Gardena Aquifer, extrapolated to be at approximately 200 ft bgs. The base of the San Pedro Formation is below 1,000 ft bgs in the area.

- **San Pedro Formation Aquifers** - Regional aquifers within the San Pedro Formation include the Hollydale, Jefferson, Lynwood, and Silverado Aquifers. Regional data suggest that the Jefferson and Lynwood are present in the area of the Pemaco Site. The shallower Hollydale aquifer may or may not be present below the site; regional cross-sections of the area show that sand units of the Hollydale aquifer may “pinch-out” and not be present (State of California, 1961).

1.4 Site Background

1.4.1 Site Physical Description

The Pemaco site is comprised of 1.4 acres located within a mixed industrial and residential neighborhood in the City of Maywood, California. Maywood is located in Eastern Los Angeles County. Figure 1 illustrates the general geographical area of the Pemaco site.

The site is currently a vacant dirt lot, with the exception of two temporary office/storage containers and a cement pad that parallels the Los Angeles River on the eastern-most side of the property.

The City of Maywood, in conjunction with the Trust for Public Land (TPL), has plans to build a 7.3-acre public recreational park in the City of Maywood adjacent to and west of the Los Angeles River just south of East Slauson Avenue. The Maywood River Park would be one segment of a proposed 51-mile greenway along the Los Angeles River. The proposed park includes Pemaco, W.W. Henry, Catellus, Lubricating Oil, Los Angeles Junction Railroad (LAJR) Right-of-Way, and Precision Arrow properties (Figure 2).

1.4.2 Site History

Pemaco, Inc. formally operated a custom chemical blending and distribution facility at 5050 E. Slauson Blvd. in Maywood, California, from the 1950s until 1991 (E&E, 1998). A wide variety of chemicals were used onsite including chlorinated and aromatic solvents, flammable liquids, oils, and specialty chemicals.

Marie B. Richardson was the owner of Pemaco, Inc. until 1984, at which time Lux International purchased the property. Lux International operated the chemical blending facility until 1991 when they went out of business. No other use of the property is documented since 1991.

Historically, the Pemaco facility consisted of a 22,000-square ft warehouse in the northern portion of the property, and 31 underground storage tanks (USTs) and at least 6 aboveground storage tanks (ASTs) in the southern part of the property (Figure 3). Large quantities of chemicals were stored in the ASTs and USTs, which ranged in size from 500 to 20,000 gallons, as well as 55-gallon drums sporadically stored around the site. A wide variety of chemicals were used onsite including chlorinated and aromatic solvents, flammable liquids, oils and specialty chemicals. Most of the chemicals brought to the site were delivered via railcar from a rail spur that branched out from the LAJR property west of the site.

1.4.3 Removal and Remedial Actions

After cessation of operations in 1991, removal and remedial actions began. Between 1991 and 1994, approximately four hundred 55-gallon drums and three aboveground storage tanks were removed from the site by order of the Los Angeles District Attorney's office. A substantial fire in 1993 destroyed much of the main warehouse building. In 1994, USEPA Region IX Emergency Response conducted a removal assessment at Pemaco at the request of Los Angeles County. As a part of this assessment, USEPA removed six 55-gallon drums, installed fencing, and secured underground storage tank (UST) fill pipes with locking well caps.

CET Environmental Services, Inc. (CET) completed additional removal activities at Pemaco between August 1997 and March 1998 under the direction of Region IX's Emergency Removal Office (E&E, 1998a, 1998b). Work included excavation and removal of over 30 USTs, building demolition, environmental sampling, and the design, installation, and operation of a soil vapor extraction (SVE) system. The SVE system operated between March 1998 and March 1999 (E&E, 1999). By the end of August 1998, the SVE system had operated for 3,230 hours (134.6 days), and removed and treated approximately 90,000 pounds of hydrocarbons and solvents from vadose zone soils at the site. The system was turned off on March 3, 1999 due to community concern regarding the possibility of dioxin releases from the thermal oxidation unit used to treat extracted soil vapor.

1.4.4 Preliminary Assessment/Site Investigation

In June of 1995, Bechtel completed a preliminary assessment/site investigation at Pemaco, which led to the listing of Pemaco into the Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS) under the I.D. number CAD980737092. Ecology & Environment's (E&E) Superfund Technical Assistance Response Team (START) completed an expanded site investigation (ESI) in 1997, which included an evaluation of Hazardous Ranking System (HRS) factors. Based on these factors, Pemaco was added to the Superfund National Priorities List (NPL) in January 1999.

1.4.5 Environmental Investigations

Numerous soil and groundwater investigations have been completed at the Pemaco site and adjacent properties to assess the extent of contamination at the Pemaco site and surrounding area. A chronological account of previous events at the Pemaco site and the adjacent properties can be found in Tables 1.0 through 1.4.

Environmental cleanup activities are on-going at the site and likely will continue for several years into the future. Future remedial activities will be integrated with the existence of the park.

1.5 Site Geology and Hydrogeology

1.5.1 Geologic Setting

Geologic cross sections (Figures 4, 5A-5F) illustrate site geology and hydrogeology as encountered in 93 continuously cored borings drilled during RI/FS activities. Table 1.5 summarizes the advanced borings and their approximate depths. The following is a simplified description of the stratigraphy and lithologic units underlying the site vicinity. The titles given to the lithologic units discussed below will be used throughout the document as they relate to drilling and sampling activities and analytical results. Table 1.6 summarizes site stratigraphy and may be used in conjunction with the discussion of each soil zone below.

1.5.1.1 Surface and Near-surface Soil

Surficial fill in the area varies in thickness from 2 to 6 ft and is typically comprised of dark yellowish brown silty sands and local gravelly sands or clayey gravels.

1.5.1.2 Upper Vadose Zone

For purposes of this report, the upper vadose zone includes the upper vadose zone sands and the perching clay. The saturated zone above the perching clay (perched groundwater zone) is included within the upper vadose zone (see Section 1.5.1.5).

Upper Vadose Zone Sands
Typical depth of the upper vadose zone is between 2 to 25 ft bgs. These native soils are predominately light olive gray to dark yellowish brown laminated to moderately bedded fine silty sands ranging from 1 to 20 ft in thickness interbedded with pale yellowish brown to light olive gray lenses of laminated to poorly bedded poorly graded sands and fine poorly graded sands with silt which are 2-in to 6-ft thick. Local discontinuous lenses of olive gray sandy silt and lean clay lenses ranging from 3 inches to 4 ft in thickness are also present within the upper vadose zone sand.

Perching Clay
Typical depth of the perching clay is between 28 to 40 ft bgs. The top of this unit is comprised of silty lean and fat clays ranging from 1 to 15 ft in thickness, which are underlain

and interbedded with olive gray to moderate yellowish brown clayey and sandy silts ranging from 1 to 8 ft in thickness. The perching clay and associated clayey silts comprise the fine-grained lithosome that ranges from 10 to 20 ft in total thickness. Local unsaturated silty sand and sands with silt lenses are found within the lithosome.

1.5.1.3 Lower Vadose Zone

Lower Vadose Zone Sand
The lower vadose zone sand is typically found between 40 to 50 ft bgs. It is predominately fine- to medium-grained, unsaturated, poorly graded sands and gravelly well-graded sands derived from granitic source rocks. The zone typically coarsens downward with poorly bedded gravelly basal units. The lower vadose zone sands are usually 1- to 14-ft thick with local intervals of silty sands and poorly graded sands with silt which are 6-inches to 3-ft thick. Local interbeds of silt lenses are 6-inches to 4-ft thick within this unit. The lower vadose zone sand appears to be continuous throughout the area as it was encountered in every boring completed in the site vicinity except in the area adjacent to MW-12 (Alamo and 60^{th} Street) where it appears to pinch out locally. The thickest local sequences are found along District Blvd. and in the area underlying 60th Street between Walker Ave. and District Boulevard. Fine silty sands comprise the unit in locations where the interval is less than 3 ft thick.

Lower Vadose Zone Fine-Grained Unit
Typical depth of the lower vadose zone fine-grained unit is between 50 to 65 ft bgs. It is comprised of sandy and clayey silts ranging from 7 to 20 ft in thickness interbedded with lean and fat clays ranging from 6 inches to 5 ft in thickness. Local discontinuous lenses of unsaturated poorly graded sands and silty sands are 0.5- to 2-ft thick within this interval. The thickest areas of the unit are predominately silt. Localized abundant organic material can also be found throughout the interval.

1.5.1.4 Lakewood Formation

‘A’ – ‘B’ Fine-Grained Unit
This zone separates the ‘A’ and ‘B’ Exposition groundwater zones (1.5.1.5) and is typically found between 70 to 80 ft bgs. It is comprised of light olive gray fat and lean moderate to very stiff clays with local interbeds of dark greenish gray clayey silt with sand. Local mottling of the gray clays with dark yellowish orange and medium yellow brown clays may distinguish this unit. This aquitard interval ranges from 5 to 10 ft in thickness and is continuous where both ‘A’ and ‘B’ Exposition groundwater zones are present.

‘B’ – ‘C’ Fine-Grained Unit
This unit is typically found between 90 to 100 ft bgs. It is predominately comprised of olive gray to dark greenish gray fat and lean clays 8- to 10-ft thick with local interbeds of sandy silts and silt with clay 1- to 5-ft thick. Total thickness of the unit is 7 to 12 ft.

‘C’ – ‘D’ Fine-Grained Unit
This unit is typically found between 105 to 125 ft bgs. It is comprised of lean and fat clays 3 to 6 ft thick interbedded with sandy and clayey silts 4- to 12-ft thick. Total unit thickness ranges from 18 to 30 ft.

‘D’ – ‘E’ Fine-Grained Unit

This unit is typically found between 145 to 160 ft bgs. It is predominately comprised of clayey silt with local interbeds of lean clays. Thickness ranges from 12 to 18 ft. Local saturated silty sand lenses to 2-ft thick are located within the interval.

Lower Exposition Fine-Grained Unit

The top of this unit is typically found at 175 ft bgs. It is comprised of clay with silt finely laminated with silt. Local lenses of medium-grained saturated poorly graded sands to 6 inches thick are found within this unit. The depth to bottom and total thickness of this unit is unknown in the site vicinity.

1.5.1.5 Saturated Zones

Perched Zone

The perched saturated interval comprises a few inches to 4 ft of the “perched zone” lithosome (perching clay described above in Section 1.5.1.2). Typical depth of the perched zone is between 25 and 30 ft bgs. This wet to saturated zone is comprised of locally laminated fine silty sands ranging from 6 inches to 4 ft in thickness. Locally, the perched zone is comprised of two perched intervals of sandy silts or silt with sand separated by a 1- to 3-ft-thick layer of “perching” clay. The perched zone is absent in some areas where it is replaced by “high points” of the underlying “perching” clay. Groundwater flow direction and hydraulic communication between different localities of the perched zone is dependent upon the geometry of the underlying perching clay. The perched zone can be characterized by low transmissivities and very limited yield. This is not a viable aquifer.

Exposition ‘A’ Zone

This is the first saturated zone encountered below the perched zone. The ‘A’ Zone is typically found between 65 and 75 ft bgs. It is comprised of light olive gray to dark greenish gray fine silty and poorly graded sands locally interbedded with well-graded sands with silt. The thickness of this zone is highly variable ranging from 3 inches to 10 ft in thickness. The thickest ‘A’ Zone intervals are comprised of interbedded poorly graded silty sands and well-graded sands. The thinnest intervals of the ‘A’ Zone are a series of 1- to 3-in-thick saturated silty sands interbedded with 0.5- to 1-ft-thick silts and clays. Overall, the ‘A’ Zone can be characterized as a series of semi-discontinuous saturated sand lenses.

Exposition ‘B’ Zone

The ‘B’ Zone is the second saturated zone below the perching layer and is typically found between 80 and 90 ft bgs. It is comprised of fine silty sands, poorly graded sands and poorly graded sands with silt ranging from 1.5 to 10 ft in thickness. The fine-grained silty sands are typically light olive gray mottled with moderate yellowish brown or moderate olive brown. Some of the thicker portions of the unit have 4-ft-thick interbeds of silt/clay. The ‘B’ Zone is continuous throughout the site vicinity, except in the area along District Blvd., south of 60th Street, where it pinches out.

A secondary saturated silty sand lens located between 90 and 92 ft bgs was consistently observed during the coring of borings MW-16 through MW-18 and RW-01 located in the southernmost portion of the Pemaco site. This secondary lens is isolated from the ‘B’ Zone described above by an overlying interval of fat clay ranging in thickness from 1 to 3 ft. Well MW-17-95 was screened solely in this zone for aquifer test purposes. This zone was informally named the ‘B_2’ Zone. The ‘B_2’ lens was not encountered in any of the offsite borings that were cored below 90 ft bgs.

Exposition 'C' Zone
The 'C' Zone is typically found between 100 and 105 ft bgs. It is comprised of saturated dark greenish gray fine silty sands, poorly graded sands and poorly graded sands with silt ranging from 2 to 6 ft in thickness. It appears to be continuous throughout the site vicinity within the 95 to 110 ft depth interval.

Exposition 'D' Zone
The 'D' Zone is typically found between 125 and 145 ft bgs. It is comprised of interbedded fine silty sands, poorly graded sands and poorly graded sands with silt, well-graded sands and gravelly sands and local well-graded sandy gravel intervals. Total thickness ranges from 6 to 15 ft. This zone is the thickest and highest yielding of all the Exposition groundwater zones encountered in the site vicinity.

Exposition 'E' Zone
The 'E' Zone is typically found between 160 and 175 ft bgs and is comprised of alternating saturated intervals of 1-ft-thick fine silty sands and well-graded sands.

1.5.2 Hydrogeologic Setting

1.5.2.1 Regional Hydrogeology

The Los Angeles–Orange County coastal plain is a structural basin formed by folding of the consolidated sedimentary, igneous, and metamorphic rocks that underlie the basin at great depths. Primary geologic/hydrogeologic units in the area, from youngest to oldest include:

- Recent Alluvium – Primarily unconsolidated braided-river and floodplain deposits. These deposits comprise the uppermost 30 to 40 ft of soil/sediment in the immediate area (Figure 5A).

- Pleistocene Lakewood Formation, including the Exposition and Gage/Gardena Aquifers – Consisting of braided river and floodplain deposits. In the Pemaco area, sediments of the Lakewood Formation generally comprise the stratigraphic interval between about 35 and 200 ft bgs (Figures 5B – 5F). Saturated intervals of the Lakewood Formation within the study area that are stratigraphically equivalent to the Exposition Aquifer do not meet the strict definition of an aquifer, because they are not capable of yielding economically significant quantities of water. The Gage/Gardena Aquifer is assumed to be located between 180 and 200 feet bgs in the site vicinity, but this has not been confirmed. The deepest borehole drilled during the RI activities went to 183 feet bgs.

- Lower Pleistocene San Pedro Formation, including the Hollydale, Jefferson, Lynwood and Silverado Aquifers – A variety of lithosomes deposited in both marine and non-marine environments. In the Pemaco area of the Central Groundwater Basin, the stratigraphic top of the San Pedro Formation is generally placed at the base of the Gage/Gardena Aquifer (basal Lakewood Fm.), estimated to occur at about 200 ft bgs. The uppermost unit of the San Pedro Formation is a 50- to 75-ft thick fine-grained lithosome, generally regarded as an aquitard. The Hollydale and Jefferson aquifers are the upper aquifers in the San Pedro Formation, and may be present below the Pemaco Site, with the top of the uppermost coarse-grained unit occurring somewhere between 250 and 325 ft bgs.

The aquifers mentioned above are all used for both municipal and industrial purposes in various parts of the Central Basin. In the Pemaco area, screened/perforated intervals in nearby production wells begin in the San Pedro Formation Aquifers, usually at depths of 350 ft bgs or deeper. The closest active well is approximately ½ mile south of the site (screen interval begins at 610 feet bgs), one of the two wells owned and operated by Mutual Maywood Water Company. The shallowest production well within 1 mile of the site is screened starting at 350 ft bgs within the uppermost aquifer of the San Pedro Formation (the Jefferson Aquifer). Figure 6 illustrates active local production wells within a 1-mile radius of the Pemaco Site. In general, the groundwater flow direction in the aquifers is southwest, towards the coast.

1.5.2.2 Hydrogeology of Study Area

There are two distinct hydrogeologic units within the study area: a perched groundwater zone and the stratigraphic equivalent of the more regional Exposition Aquifer. The perched groundwater zone is typically found between 25 and 40 ft bgs within the study area. Beneath the perched groundwater zone, there are five distinct saturated intervals present within the study area that are typically found between 65 and 175 ft bgs that are separated by silt/clay intervals. These saturated zones do not comprise a viable aquifer, as the groundwater yield does not produce economically significant quantities of water to local production wells. However, as these zones are stratigraphically equivalent with the more regional Exposition Aquifer, they have been have been informally named from top to bottom, the Exposition ‘A’ through ‘E’ Zones. Seventy-eight monitoring wells are currently installed within the perched groundwater zone and the five groundwater zones of the Exposition Aquifer.

Perched Groundwater

Groundwater in the perched zone occurs in semi-continuous and discontinuous lenses of poorly graded sand, silty sand, and sandy silt. These lenses are located at different depths ranging from 20 and 40 ft bgs and 5 inches to 5 ft in thickness. The geometry of the perched zone is controlled by the highly irregular and undulating top surface of the underlying, laterally extensive perching clay (Figure 7A). Measurements of depths to groundwater in the perched zone in the Pemaco site vicinity ranged from 18.48 ft bgs (B-31, April 2001) to 39.31 ft bgs (B-17, May 2001) since measurements began in September 2000. Groundwater fluctuations of greater than 5 ft have been observed since routine gauging started.

The complex hydrogeology of the perched zone causes highly variable groundwater gradients. Figure 7B illustrates the perched zone groundwater gradient for the April 2002 monitoring event. The overall general component of apparent groundwater flow in the perched zone is towards the southwest, but there are many localized areas that indicate that the apparent groundwater flow is in multiple directions.

Exposition Zones ‘A’ through ‘E’

Although the groundwater zones present between 65 and 175 ft bgs in the vicinity of the site do not comprise a viable aquifer, they are stratigraphically connected to the more regional Exposition Aquifer. As such they have been informally labeled Exposition Zones ‘A’ through ‘E’ and consist of five distinct saturated zones that are separated by silt/clay intervals. The ‘A’ Zone is typically found between 65 and 75 ft bgs. It is comprised of fine silty and poorly graded sands locally interbedded with well-graded sands. The thickness of this zone is highly variable ranging from 3 inches to 10 ft in thickness. This interval can be characterized as a series of semi-discontinuous saturated sand lenses. The ‘B’ zone is typically found between 80 and 90 ft bgs. It is comprised of fine silty sands, poorly graded sands and poorly graded sands with silt ranging from 1.5 to 10 ft in thickness. The ‘B’ Zone is more uniform and laterally continuous than the ‘A’ Zone. These two zones are the predominant zones of concern and together are informally named the Upper Exposition Aquifer.

Potentiometric surface measurements in the semi-confined Exposition Aquifer ‘A’ Zone ranged from 53.43 ft bgs (MW-7-75, May 2001) to 64.27 ft bgs (MW-15-70, January 2002) since measurements began. Groundwater fluctuations of up to 7 ft have been observed in the ‘A’ Zone since measurements began in May 2001. Figure 8A illustrates the ‘A’ Zone groundwater gradient for the April 2002 monitoring event. Gradient ranged from 0.0043 to 0.011 ft per ft (ft/ft) from May 2001 to April 2002. Apparent groundwater flow directions have been consistently towards the southwest and south-southwest.

Potentiometric surface measurements in the confined Exposition Aquifer ‘B’ Zone ranged from 57.71 ft bgs (MW-13-85, May 2001) to 72.40 ft bgs (MW-14-90, January 2002) since measurements began. Groundwater fluctuations of more then 4 ft have been observed in the ‘B’ Zone since measurements began in May 2001. Figure 8B illustrates the ‘B’ Zone groundwater gradient for the April 2002 monitoring event. Gradients ranged from 0.0063 to 0.0092 ft/ft from May 2001 to April 2002. Apparent groundwater flow directions have been consistently towards the southwest.

The remaining three zones, ‘C’, ‘D’, and ‘E’ are typically found from 95 to 110 ft bgs, 125 to 145 ft bgs, and 160 to 175 ft bgs, respectively. The ‘C’ zone is comprised of saturated fine silty sands, poorly graded sands and poorly graded sands with silt ranging from 2 to 6 ft in thickness. It appears to be continuous throughout the site vicinity within the 95 to 110 ft depth interval. The ‘D’ Zone is typically comprised of interbedded fine silty sands, poorly graded sands and poorly graded sands with silt, well-graded sands and gravelly sands, and local well-graded sandy gravel intervals. Total thickness ranges from 6 to 15 ft. This zone is the thickest and highest-yielding of all the Exposition Aquifer lithosomes encountered in the site vicinity. The ‘E’ Zone is typically comprised of alternating saturated intervals of 1-ft-thick fine silty sands and well-graded sands. Due to the limited number of monitoring wells screened within the Exposition Aquifer ‘C’ through ‘E’ Zones, no gradient data is available for these zones.

Hydraulic Parameters

A series of groundwater slug, pumping, and recovery tests were performed at the Pemaco site between December 12th and 24th, 2001 (see Section 3.1.1.1). Types of tests performed included:

- Background/diurnal logging of “static” groundwater levels in the ‘A’ and ‘B’ Zones,
- Slug testing of six ‘A’ Zone wells,
- Step drawdown pump testing of the ‘B’ Zone while monitoring ‘A’ and ‘B’ Zone wells,
- Constant rate pump testing (72 hrs) of the ‘B’ Zone while monitoring ‘A’ and ‘B’ Zone wells,
- Post-pumping recovery monitoring of all wells monitored during pumping test, and
- “Stress” pumping of the ‘B’ Zone to determine maximum sustainable pumping rates.

Results of data analysis are:

- Sustainable pumping rates from the ‘B’ Zone are about 1 gallon per minute (gpm) and about 0.5 gpm from the ‘A’ Zone.

- Calculated hydraulic conductivity (K) values for the 'A' Zone range from 8.3 E-04 to 2.3 E-03.
- Calculated hydraulic conductivity (K) values for the 'B_1' Zone range from 1.4 E-02 to 1.0 E-01.
- Calculated hydraulic conductivity (K) values for the 'B_2' Zone range from 6.7 E-03 to 6.6 E-03.
- Linear Groundwater Velocities calculated for the combined 'B_1' and 'B_2' Zones averaged 0.47 feet per day (171 feet per year).

1.6 Nature and Extent of Contamination

Analytical results of the environmental samples collected during the RI indicate that chemical concentrations originating from past industrial practices at the Pemaco property have impacted soil and groundwater at the site, as well as offsite, below adjacent industrial and nearby residential properties. Based on the operational and land use history of Pemaco and the adjacent industrial properties, contamination sourced to Pemaco has been delineated from contamination sourced to the neighboring former industrial properties. In addition, contaminant plumes have been delineated to levels indicative of background; soil to levels below background data for California soils (Bradford et al., 1996); groundwater to levels below USEPA and CalEPA drinking water standards (e.g., maximum contaminant levels).

Figure 9 illustrates the conceptual site model for the Pemaco site. Fifty-six chemicals of potential concern (COPCs) have been identified based on the comparison of analytical results to USEPA Region IX Preliminary Remediation Goals (PRGs) and State of California and USEPA Maximum Contaminant Levels (MCLs). COPCs include various species of metals, solvents/non-halogenated volatile organic compounds (NHVOCs), semi-volatile organic compounds (SVOCs), and volatile organic compounds (VOCs). Tables 1.7A through 1.7H list COPCs per media zone (ambient air and soil vapor media zones included in tables (Tables 1.7A and 1.7B) – these mediums will be addressed through treatment of soil and groundwater.

The following sections describe the nature and extent of contamination based on analytical data for the following environmental media: surface and near-surface soil, upper vadose zone soil, lower vadose zone, perched groundwater, and Exposition Aquifer groundwater.

A general breakdown of environmental media and/or "zones" and the relative types and distribution of COPCs in each is as follows (next page):

Media or Zone	Number of COPCs Present	Types of COPCs	Depth	Extent
Surface and Near-surface Soil	11	SVOCs and Metals	6 inches to 2.5 ft bgs	Onsite and adjacent industrial properties
Upper Vadose Zone	21	NHVOCs, VOCs, SVOCs and Metals	2.5 ft to 35 ft bgs	Onsite
Lower Vadose Zone	11 (DAF 1)	VOCs and Metals	35 ft to 65 ft bgs	Onsite
Perched Groundwater	32	NHVOCs, VOCs, SVOCs and Metals	25 ft to 35 ft bgs	Mixed VOC plume onsite, extends 200 ft southwest of site
Exposition Groundwater Zones	20	NHVOCs, VOCs and Metals (Metals are likely background levels)	65 ft to 100 ft bgs	VOC plume (primarily trichloroethene) onsite, extends ~1100 ft to southwest of site
bgs = below ground surface DAF = dilution attenuation factor for soil screening levels to assess threats to groundwater				

1.6.1 Surface and Near-Surface Soil

A total of 150 samples were obtained within a collection of discrete-sample grids (approximately 25 ft by 25 ft) and 5 composite-sample grids (approximately 50 ft by 100 ft) laid across the Pemaco site and adjacent railroad right-of-way. Samples were analyzed for and indicated elevated concentrations of SVOCs and metals in both soil zones. A statistical summary of surface and near-surface soils is included as Tables 1.8A and 1.8B, respectively. These tables include the minimum and maximum value for each analyte, the location of the minimum and maximum concentrations, and the frequency of detected values by analyte.

Four metals and seven SVOCs were detected above Site cleanup criteria for surface and near-surface soils, or Region IX PRGs for Residential Soils (with the exception of iron, for which the cleanup criteria is background (83,100 mg/kg)) (Bradford et al., 1996).

Polyaromatic hydrocarbons (PAHs) were the most prevalent SVOCs detected above PRGs for Residential Soil in both surface and near-surface samples. Although there was no indication of historical use of PAHs at Pemaco or adjacent industrial properties, the compounds were detected throughout the Pemaco site. A possible source of the PAH concentrations could be from creosote treated railroad ties located along the LAJR property and the associated spurs branching off each property, or from the warehouse fire that occurred on the Pemaco site in 1993. However, PAHs were also detected during previous environmental assessments of adjacent properties in areas distant from the railway and former warehouse. It is likely that PAHs can be found in shallow soil throughout the Maywood area due to vehicle exhaust, previous fires and paving activities that have occurred over the years. These concentrations appear to be only surficial phenomena.

Metals exceeding PRGs for Residential Soil in surface soils include iron, lead, and manganese. Iron and arsenic concentrations exceed PRGs in near-surface soils. It is unlikely that the elevated metal concentrations are a result of previous activities on the Pemaco site. The elevated metal concentrations could be associated with the historical use of railcars and the presence of the train tracks. However, concentrations may also be contributed to high naturally occurring background levels in the soil.

Figure 10 illustrates the grid locations where samples indicated concentrations above Region IX Preliminary Remediation Goals (PRGs) for Residential Soil. As concentrations of SVOC and metals in surface and near-surface soils indicate, the majority of surficial soil contamination appears to lie along the periphery of the Pemaco site. This would be consistent with the fact that clean fill was placed over much of the site during previous removal actions of the former warehouse foundation, UST excavation and soil removal within the central portion of the site.

1.6.2 Upper Vadose Zone Soil

A total of 173 discrete soil samples were collected from upper vadose zone soils (approximately 2.5 ft to 35 ft bgs) from three depth intervals – approximately 5 feet bgs, near the capillary fringe (25 feet bgs), and at the top of the perching clay (approximately 35 feet bgs). Samples were analyzed for VOCs, SVOCs, NHVOCs, and metals. A statistical summary of results for upper vadose zone soils is included as Table 1.9A. This table includes the minimum and maximum value for each analyte, the location of the minimum and maximum concentrations, and the frequency of detected values by analyte.

Analytical results were compared to Site cleanup criteria for upper vadose zone soils, or USEPA Region IX Soil Screening Levels (SSLs), which are used to screen subsurface soil as a threat to groundwater. The Dilution Attenuation Factor (DAF) 20 SSLs were selected for comparison because these soils are not directly adjacent to a drinking water source and dilution of the contaminant is occurring before it reaches the source. Principal analytical data are bulleted below by analyte group:

- Arsenic and total chromium were the only target metals detected above DAF 20 SSLs. Samples that reported these concentrations were collected from borings located offsite. The distance of these samples from the Pemaco site and the sporadic distribution of concentrations suggest that detected concentrations are likely background levels and not from a Pemaco release.

- Trace to low concentrations of NHVOCs were detected in the southwest portion of the Pemaco site. Acetone was the only solvent that exceeded an SSL; elevated concentrations of acetone have been attributed to bentonite pellets (see note below) used during well installation (TN&A, 2002b).

  Note: During the first sampling event (May-June 2001), several of the newly installed Exposition Aquifer wells had elevated acetone and isopropyl alcohol concentrations. Due to these high concentrations appearing in the down-gradient wells, it was believed that a large acetone and isopropyl alcohol plume existed that was not fully delineated. Due to the documented historical uses and storage of these two chemicals on the Pemaco and other adjacent industrial sites (W.W. Henry property, Catellus property, Dunn-Edwards property), it was plausible that a large plume could exist. A second round of in-situ CPT groundwater sampling was performed in November 2001 to delineate this apparent plume. The additional CPT investigation results showed trace concentrations (4 to 12 ug/L) that were likely due to the ambient sampling conditions. During the time of the CPT investigation, the results of the September-October 2001 sampling event were received and it was found that the acetone and isopropyl alcohol concentrations had decreased by an order of magnitude from the May-June 2001 sampling results in each of the newly installed wells. This anomalous decrease caused other possible reasons for the concentrations to be researched. It was found through discussions with drilling companies and well construction materials manufacturers that food-grade isopropyl alcohol is sometimes used for the time release coatings of bentonite pellets.

This was confirmed by the Occupational Safety and Health Administration (OSHA) material safety data sheet (MS/DS) for the “Coating for Pel Plug TR30/60”. This coating occasionally contains acetone as an impurity according to the sources consulted. These time-release pellets were used to seal the saturated annulus space between the well casings and the borehole walls for the Exposition Aquifer wells.

During the November 2001 well installation activities for the aquifer test wells (MW-14-80 through MW-19-85 and RW-01-85), TN&A personnel placed several of the coated bentonite pellets in a certified clean glass jar filled with laboratory grade de-ionized water. The pellets were allowed to soak in the container for approximately four hours; a sample was then collected from the water in the glass jar and analyzed for VOCs by EPA Method 8260. The results indicated that acetone was detected in this water at 310 ug/L. This test validated the hypothesis that the elevated acetone levels were caused by the coated bentonite pellets.

- The most prevalent SVOCs within the upper vadose zone soils were polyaromatic hydrocarbons (PAHs), the majority of which were located within 5 to 6 feet bgs adjacent to the central-west part of the Pemaco site. As stated in the surface/near-surface soil section, there was no indication of historical use of PAHs at the Pemaco facility or the adjacent industrial properties.

- VOCs that exceeded Region IX DAF 20 PRGs included the following: 1,1-DCE, acetone, benzene, cis-1, 2-DCE, ethylbenzene, methylene chloride, PCE, toluene, TCE, vinyl chloride, and xylenes. The most prevalent and widespread concentrations consisted of chlorinated VOCs, although several “hot spots” of non-chlorinated VOCs (BTEX) are present within the upper vadose zone soils.

As discussed above, VOCs are the most prevalent and widespread contaminants within upper vadose zone soils at the Pemaco site and surrounding area. The release of VOCs at Pemaco is likely a result of leaking USTs and spills associated with the loading area located in the southwest corner of the site and leaking aboveground storage tanks and drum storage in the north-central portion of the site. Figure 11A illustrates total the aereal extent of VOC-contaminated soils within this zone. Five primary areas of VOC contamination have been identified in the upper vadose zone, these are:

1. Below the central part of Pemaco site and extending approximately 80 ft offsite (to the west) between 25 and 35 ft bgs, primarily comprised of chlorinated VOCs;

2. A small area below the central part of the Pemaco around 15 ft bgs, primarily comprised of toluene, ethylbenzene and xylenes;

3. A small area below and adjacent to the central-west part of the Pemaco site (below the rail tracks) around 5 ft bgs, primarily comprised of SVOCs;

4. Below the south part of Pemaco site and extending approximately 200 ft offsite (to the west/southwest) between 25 and 35 ft bgs, primarily comprised of chlorinated VOCs; and

5. An offsite area resulting from releases at the adjacent former W.W. Henry-owned property, consisting primarily of benzene, toluene, and hexane.

1.6.3 Lower Vadose Zone Soil

A total of 112 discrete soil samples were collected from vadose zone soils between approximately 35 and 65 ft bgs. Soil samples were collected at 10-foot intervals beginning at 35 feet bgs and continuing to approximately 65 feet bgs and analyzed for VOCs, SVOCs, NHVOCs, and metals. A statistical summary of lower vadose zone soils is included as Table 1.9B. This table includes the minimum and maximum value for each analyte, the location of the minimum and maximum concentrations, and the frequency of detected values by analyte.

Analytical results were compared to Site cleanup criteria for lower vadose zone soils, or USEPA Region IX DAF 20 SSLs for soils to 50 ft bgs and USEPA Region IX DAF 1 SSLs for soils 50 ft or greater. The DAF 1 SSLs assume that the contaminated soil source is directly adjacent to a drinking water source, such as a regional aquifer, and no dilution is occurring along the migration pathway between the source soil and the drinking water source. Due to the saturated zone present between approximately 55 and 65 feet bgs and the potential future use of the Exposition Aquifer as a viable water source, lower vadose zone soils present at 50 feet bgs or greater were also compared to DAF 1 SSLs. Primary analytical data are bulleted below by analyte group:

- All 24 metal target analytes were detected above method detection limits, although only total chromium was detected above DAF 20 SSLs. Upon comparison of lower vadose zone soils greater than 50 feet bgs with DAF 1 SSLs, the following metals were filtered: antimony, arsenic, barium, cadmium, total chromium, and nickel. Total chromium exceeded the DAF 1 SSL for chromium at every boring where samples were collected below 50 feet. With exception to antimony, all other metals were detected at concentrations exceeding their applicable SSLs at all borings sampled below 50 feet except for one to two locations. The widespread presence of metals within lower vadose zone soils suggests that these metals are likely background and not from a Pemaco release.

- Trace to low concentrations of SVOCs and NHVOCs were detected; however, no concentrations exceeded DAF 20 or DAF 1 SSLs.

- VOCs that exceeded Region IX DAF 20 SSLs include: benzene, cis-1, 2-DCE, 1,2-DCA, methylene chloride, TCE, and vinyl chloride. Upon comparison of lower vadose zone VOC concentrations greater than 50 feet bgs with DAF 1 SSLs, all VOCs discussed above reported concentrations exceeding DAF 1 SSLs with exception of vinyl chloride. This comparison also revealed additional offsite contamination, although maximum exceedances remain concentrated within the southwest corner of the Pemaco site between the depths of 55 and 60 feet bgs.

Like upper vadose zone soils, VOCs are the most prevalent and widespread contaminant within lower vadose zone soils. Figure 11B illustrates the extent of VOC-contaminated soil within the lower vadose zone. Two areas of contamination have been identified in the lower vadose zone (between 35 and 65 ft bgs). One area is located along the southern boundary of the Pemaco site, which extends offsite to the south/southwest and is comprised of chlorinated VOCs. The other area is related to the W.W. Henry free product plume and was detected along 59th Place adjacent to the W.W. Henry property. The extent of this contamination was not fully evaluated, as it is not part of the Pemaco RI/FS scope.

1.6.4 Perched Groundwater

A total of 42 groundwater monitoring wells have been installed within the perched groundwater zone. Utilizing this network, eight quarterly groundwater sampling events (to date) have enabled the complete delineation of contaminant "plumes", which originate from the Pemaco property.

PCE, TCE and vinyl chloride are the most prevalent and widespread compounds detected within the perched groundwater zone. "Hot spot" areas within the plumes have had groundwater concentrations exceeding 1,000 µg/L. The dissolved-phase portions of the plumes extend offsite and have migrated beneath adjacent properties extending up to 250 ft to the south and up to 200 ft southwest of the Pemaco property. Contaminant plumes originating from the Pemaco property have also co-mingled with other chlorinated and non-chlorinated contaminant plumes that have resulted from historical industrial uses of neighboring properties (former W.W. Henry and Lubricating Oil Services properties).

A more detailed description of the individual plumes is provided below:

- There appears to be three separate areas where PCE was released (Figure 12A) including the north-central portion of the Pemaco property, the northeast portion of the W.W. Henry property and in District Blvd (approximately half a block south of the Pemaco property). The highest concentrations (>500 µg/L) are found in the north-central portion of the Pemaco property in the vicinity of wells B-01 and SV-2. This area coincides with the former aboveground storage tanks and drum storage areas. The northern extent of this plume is approximately where the northern Pemaco property boundary lies. The western extent of this plume appears to co-mingle with another separate PCE plume that probably originated from the W.W. Henry property. This is indicated by the increase in concentrations going from northeast to southwest across the Pemaco and Railway properties onto the W.W. Henry property. This W.W. Henry hot spot also coincides with a documented release of PCE in soil adjacent to the former rail spur that ran along the northern boundary of the W.W. Henry property. The third identified perched zone PCE plume is located in a small area around well B-25. This small plume is likely to have originated from a release on the former Lubricating Oil Services property.

- TCE is the most prevalent VOC in the perched zone. The perched TCE plume extends throughout most of the Pemaco site and adjacent areas (Figure 12B). The highest concentrations (>100 µg/L) are found in the extreme southern portion of the Pemaco site and to the south and southwest of the Pemaco site. The "hot spot" of the perched TCE plume appears to be limited to an area between the 59th Place and Walker Avenue intersection, and the portion of District Blvd. north of B-25. This plume may have originated from the former loading dock located in the extreme southwest of the Pemaco property or from spills that could have occurred along the railway. *In-situ* groundwater samples were collected from selected residential lots in July 2001 to delineate the TCE plume in the residential area. The TCE plume is truncated to the west by the floating free product plume originating from the W.W. Henry property, as identified during RI activities and confirmed by environmental investigations performed by W.W. Henry environmental contractors (LFR, 2001). A second area of elevated concentrations (>50 µg/L) coincides with the north-central portion of the Pemaco site in the SV-2 and B-01 areas. This TCE plume may be associated with the dechlorination of the PCE plume in that area.

- Vinyl chloride is one of the end daughter products in the degradation process of PCE and TCE. The vinyl chloride plume in the perched zone (Figure 12C) is probably due to the degradation of PCE and TCE (and subsequently DCE) and not from a release of vinyl chloride, which is a gas at room temperature and pressure. The "hot spot" (>100 µg/L) of the vinyl chloride plume appears to be in a small area near B-21. This well has elevated levels of toluene, which may be aiding in the degradation process of TCE and PCE causing the elevated vinyl chloride concentrations. The vinyl chloride plume terminates west of the Pemaco site at the free product plume originating from the W.W. Henry property.

A statistical summary of perched groundwater is included as Table 1.10A. This table includes the minimum and maximum value for each analyte, the location of the minimum and maximum concentrations, and the frequency of detected values by analyte.

1.6.5 Exposition Groundwater Zones

A total of 36 groundwater monitoring wells have been installed in the five Exposition groundwater zones present in the vicinity of the Pemaco site. Eight quarterly groundwater sampling events (to date) have been conducted using this well network. Plumes have been delineated in the upper Exposition groundwater zones ('A' and 'B'), which exist as several individual semi-confined/confined sand zones from 65 to 100 ft bgs. These contaminant plume boundaries are defined to concentrations below USEPA and CalEPA drinking water standards. Although the LA River Channel limits upgradient monitoring to an extent, CPT testing locations north of the Pemaco site and east of the LA River indicate that VOC concentrations are below detection levels.

The most extensive contaminant plumes are found in the upper zones of the Exposition Aquifer ('A' and 'B' Zones) and are primarily comprised of TCE and its daughter products. The plume of largest lateral extent is approximately 1,300 ft long and 750 ft wide within the Exposition 'B' Zone. The dissolved-phase portion of this plume extends towards the southwest of the Pemaco property and underlies a two-block area that is used for residential housing. The "hot spot' area of this plume is directly below the southernmost portion of the Pemaco property and contains TCE at concentrations exceeding 20,000 µg/L. Figures 13A and 13B illustrate TCE plumes for the 'A' and 'B' Zones, respectively.

A more detailed summary of contamination within each Exposition groundwater zone is bulleted below by zone.

'A' Zone:

- The compounds PCE, TCE and their associated daughter products (1,1-DCE, cis-1,2-DCE, trans-1,2-DCE and vinyl chloride) are the only chlorinated compounds that are widespread and consistently detected in the 'A' Zone above regulatory levels. Detections of hexane and cyclohexane are the only non-chlorinated compounds that are consistently detected in the Exposition 'A' Zone, although concentrations are below regulatory levels. Chloroform has been consistently detected over the PRG of 0.16 µg/L, but it only appears in one well (MW-5-85).

- TCE is the prevalent compound in the 'A' zone indicated by its high concentrations (21,000 µg/L) and large spatial area. PCE is consistently detected in the 'A' zone, but the concentrations are relatively low (<10 µg/L) compared to the TCE concentrations

(>20,000 µg/L). The “hot spot” concentrations (>10,000 µg/L) of the Exposition ‘A’ Zone TCE plume is limited to the southernmost portion of the Pemaco property and extends southward to the south side of 59th Place and westward to the 59th Place and Walker Avenue intersection (Figure 13A). This “hot spot” area is consistent with a release in the southernmost portion of the Pemaco site possibly from the former loading dock, former drum storage area or one of the southernmost former USTs. The farthest that the dissolved-phase fringes of the plume extend offsite is southward where it terminates before 60th Place. The ‘A’ Zone TCE plume does not appear to extend in the southwest direction consistent with its gradient. This is likely due to the irregular geometry and discontinuous nature of the ‘A’ Zone sand lenses.

- There were no SVOCs detected above California MCLs or PRGs in the Exposition ‘A’ Zone.

- There were only two NHVOCs detected in the ‘A’ Zone that exceeded PRG screening levels, these were acetone and acrylonitrile. These concentrations above PRGs were only detected during the first sampling event following the installation of wells and are attributable to the well construction materials (TN&A, 2002b). Furthermore, these two wells are the furthest down-gradient wells from the Pemaco property. This spatial distribution of the acetone detected concentrations support the premise that these concentrations are anomalous.

- Metal concentrations in the Exposition ‘A’ Zone exceeded screening levels (MCLs and PRGs) for arsenic and hexavalent chromium. The spatial distributions of these concentrations appear to coincide with chlorinated VOC plume “hot spot” and could possibly be associated with a release or could be a byproduct of the chlorinated VOC release. Changing native state geochemical parameters could have caused acidic conditions that may cause metal concentrations to be leached from the soil and cause higher than native background metals in solution. These elevated metal concentrations could also be high natural background levels.

‘B’ Zone:

- The groundwater concentrations of VOCs are similar to the concentrations found in the ‘A’ zone with TCE being the most prevalent and widespread compound. The dissolved-phase fringes of the TCE plume extend over a much greater area in the ‘B’ Zone than in the ‘A’ Zone. Less prevalent concentrations that are consistently detected in the ‘B” Zone include: hexane, cyclohexane, and benzene.

- The “hot spot” concentrations (>10,000 µg/L) of the Exposition ‘B’ Zone TCE plume mirrors the ‘A’ Zone “hot spot” area (Figure 13B). The farthest that the dissolved-phase fringes of the ‘B’ Zone TCE plume extend offsite is southwestward where it terminates near the Alamo Avenue and 60th Place intersection. The total size of this elliptical plume is estimated to be 1,290 feet long and 750 feet wide in map view. The geometry of the ‘B’ Zone TCE plume appears to be consistent with the southwest groundwater gradient indicated by the groundwater measurements in the ‘B’ Zone wells. The estimated surface area of the ‘B’ Zone TCE plume is approximately 17.7 acres (771,004 sq. ft). This larger plume size is further indication that the ‘B’ Zone sand lenses are more uniform and continuous than the ‘A’ Zone sands.

- The consistent detections of elevated benzene, hexane and cyclohexane in samples from well MW-06-85 indicate that the non-chlorinated contamination, which is prevalent in the perched zone underlying the eastern portion of the W.W. Henry property (free product area), has migrated down to the Exposition groundwater zones. Further evidence of this migration is indicated by the benzene concentrations found in each of the soil samples collected from 25 to 65 feet bgs from the MW-06 boring.

- There were only two NHVOCs detected in the 'B' Zone that exceeded PRG screening levels, these were acetone and acrylonitrile. The same discussion applies for these two compounds as discussed in the Exposition 'A' Zone section above.

- There were no SVOCs detected above California MCLs or PRGs in the Exposition 'B' Zone during any of the quarterly groundwater sampling events.

- Metal concentrations in samples from the Exposition 'B' Zone exceeded screening levels (MCLs and/or PRGs) for aluminum, arsenic, hexavalent chromium, manganese, and thallium. The spatial distributions of the arsenic concentrations are not consistent with a release based on the fact that the highest concentrations are found in samples from wells outside of the Pemaco "hot spot" area. The hexavalent chromium concentrations appear to coincide with chlorinated VOC plume "hot spot" and could possibly be associated with a release or could be a byproduct of the chlorinated VOC release. The spatial distribution and limited occurrences of elevated aluminum, manganese and thallium concentrations indicate that these are likely high natural background levels.

'C' Zone:

- There are only two wells screened in the Exposition Aquifer 'C' Zone. These wells are located over 800 feet downgradient to the south (MW-11-100) and southwest (MW-10-110) of the Pemaco site. No VOCs exceeding MCLs or PRGs have been detected in samples from well MW-11-100. The only VOCs that have been consistently detected at concentrations at or exceeding detection levels are TCE and benzene in samples from MW-10-110. These concentrations are detected at trace levels and may represent the dissolved-phase fringes of the TCE plume from the Pemaco site and the benzene plume from the W.W. Henry property. The trace benzene detections may also be a result of sampling conditions at the surface during sample collection. This well is in an area of high traffic and the benzene concentrations could be a product of vehicle exhaust that occurred during sampling events (thereby cross-contaminating the sample at the surface).

- It should be noted that TCE and cis-1,2-DCE concentrations in samples from well MW-10-110 have shown an increasing trend. This may be due to migration of the outermost plume fringe, seasonal fluctuations or sampling and analysis inconsistencies.

- The only NHVOCs detected in the 'C' Zone that exceeded PRG screening levels was acetone, which can be attributed to the well construction materials (see discussion above pertaining to acetone concentrations and their association with bentonite pellets).

- There were no SVOCs detected above California MCLs or PRGs in the Exposition 'C' Zone during any of quarterly groundwater sampling events.

- Metal concentrations in samples from the Exposition ‘C’ Zone exceeded screening levels (MCLs and/or PRGs) for arsenic and hexavalent chromium. These wells are located over 800 feet away from the Pemaco property and contain little or no VOC contamination indicating that these concentrations are likely background levels and not from a Pemaco release.

‘D’ and ‘E’ Zones:

- There are three wells screened in the Exposition Aquifer ‘D’ Zone (MW-05-135, MW-07-130 and MW-12-150) and only one well screened in the Exposition Aquifer ‘E’ Zone (MW-10-170). No VOCs exceeding MCLs or PRGs have been detected in samples from any of these wells. The only VOCs detected in these wells have been at trace levels (<7 μg/L). The trace concentrations that appear in samples from MW-07-130 could be related to the Pemaco plume, however, more temporal data needs to be collected for confirmation.

- The only NHVOCs detected in the ‘D’ and ‘E’ Zones that exceeded PRG screening levels acrylonitrile and ethyl acetate. These detections were likely a product of matrix interferences and have not been confirmed in other sampling events. These concentrations were also estimated values below the method detection limit and were never detected in subsequent sampling events.

- The only detected SVOC detected was bis(2-Ethylhexyl)phthalate in well MW-05-135 during the May-June 2001 event. This occurrence was never confirmed in subsequent sampling events.

- Metal concentrations in samples from the Exposition ‘D’ and ‘E’ Zones exceeded screening levels (MCLs and/or PRGs) for arsenic and hexavalent chromium. As discussed above for the Upper Exposition groundwater zones, it is likely that these metal concentrations are background levels. The spatial distributions of these concentrations are not consistent with a release.

A statistical summary of each Exposition groundwater zone is provided in Tables 1.10B through 1.10E. Each table includes the minimum and maximum value for each analyte, the location of the minimum and maximum concentrations, and the frequency of detected values by analyte.

1.7 Contaminant Fate and Transport

The large volume and widespread spatial distribution of physical and chemical data generated during RI activities allows for accurate assessment of contaminant extent and transport/migration pathways at Pemaco. However, due to the uncertain timing of individual chemical releases, irregular/complex stratigraphy/hydrogeology, and the relative lack of long-term monitoring data, only estimates can be made regarding contaminant fate/migration. However, the last nine quarterly sampling events (to date) indicate that plume fringes are relatively stable, given seasonal fluctuations, as illustrated in Graphs 1 through 3. Note: Graph 3 illustrates an elevated TCE concentration (April 2002, 15 μg/L); this is considered anomalous, as the following four quarterly sampling events have indicated TCE concentrations of 2 μg/L. Additional groundwater sampling events over time will allow for the determination of whether dissolved-phase contaminants are continuing to migrate, both laterally and vertically, in the various groundwater zones, or if groundwater plumes are, in fact, stable.

1.8 Baseline Risk Assessment

A baseline risk assessment was performed to quantify potential risks to human health that may be associated with chemicals in soil, soil vapor and groundwater at and adjacent to the Pemaco site. A summary of the risk assessment assumptions, methods and results is presented below.

1.8.1 Exposure Assessment

The expected future land use for the Pemaco site is well known. The Pemaco property is to be combined with several other former industrial properties and redeveloped as the Maywood Riverfront Park (Figure 2). The plan for the park includes a playground area, playing fields, basketball courts, native plants landscaping, picnic areas, restrooms, and a parking area. Although not specifically included in the current plan, addition of a swimming pool in the future is a possibility. While the planned future land use is as a park, residential use of the property cannot be excluded, as the site is adjacent to a residential community and the City of Maywood may rezone the property for residential development in the future.

Currently the Pemaco site is fenced and access is limited. The only current onsite use of the Pemaco site is by local gangs of adolescents who trespass on the site.

Based on current, proposed, and possible land uses, one current land-use scenario and three potential future land-use scenarios were developed to evaluate potential onsite exposure of human receptors. In addition, one current offsite exposure scenario was developed to evaluate potential risks to residents presently living in the vicinity of the Pemaco site. Each of the five exposure scenarios, both current and future, and their respective pathways are listed below.

1. The current trespasser scenario evaluates exposure to surface soils by the ingestion, dermal, and inhalation pathways.
2. The future park user scenario evaluates exposure to surface soil by the ingestion, dermal, and inhalation pathways.
3. The future excavation worker scenario evaluates exposure to surface and subsurface soils (to 15 feet bgs) by the ingestion, dermal, and inhalation pathways.
4. The future onsite residential scenario evaluates exposure to surface soils and to groundwater within the Exposition ‘A’ and ‘B’ Zones by the ingestion, dermal, and inhalation pathways. Vapor intrusion by volatile chemicals detected in onsite shallow soil gas was also evaluated for the future onsite residential scenario.
5. The current offsite residential scenario evaluates risks posed by potential inhalation exposure to chemicals volatilizing from the onsite subsurface soil and perched groundwater or volatilizing from perched groundwater plumes that are migrating offsite. There are currently no water supply wells in the Exposition ‘A’ and ‘B’

groundwater zones; therefore, exposure to groundwater in these zones was not evaluated.

Based on the extensive database available for the Pemaco site, fate and transport modeling were not required. The onsite risks to human health were evaluated, therefore, on the basis of the measured concentrations of chemicals in the surface soil, subsurface soil, soil gas, and groundwater in the perched zone and Exposition 'A' and 'B' Zones. Offsite risks were evaluated on the basis of measured concentrations of chemicals in indoor and outdoor air samples and soil gas samples collected on the Pemaco site and nearby residential locations.

Two general types of "receptors" were selected as representative examples of the general population. A "reasonable maximum exposure (RME) receptor" was designed to represent people who may have high exposures to COCs. A "central tendency (CT) receptor" was designed to represent people who may have what are considered to be average exposures to COCs. The results of these two cases provide a realistic range of general exposures to COCs and, consequently, a range of human health risks associated with those general exposures. Using the predicted distributions of various concentrations in each media zone, the RME receptor was assumed to be exposed to the 95th percentile concentration of each COC and the CT receptor was assumed to be exposed to the median concentration.

RME and CT exposure parameters were developed for all five exposure scenarios as bulleted below.

- The trespasser scenario was developed using exposure parameters representative of the frequency and duration of adolescent gangs per consultation with the City of Maywood, local police, and church groups.

- For the future park user scenario, outdoor athletic activities are likely to be the most intensive use of the park. Because the residential neighborhood near Pemaco is predominately Latin American and soccer in an intrinsic part of the Latin American culture, playing soccer was selected as an activity representative of the RME conditions. Because the Pemaco site is adjacent to a residential community, residential exposure duration parameters were applied. It was also assumed that the park would be accessible to small children.

- Trespassers and park users are expected to have contact only with the surface soil. In contrast, an excavation worker scenario was evaluated for potential risks due to exposure to subsurface soils up to a depth of 15 feet. Although an excavation worker may only spend a few days or weeks on the Pemaco site, exposure over a career was evaluated. This reflects the potential that an excavation worker in a metropolitan area such as Los Angeles may frequently excavate on properties that are being redeveloped after previous industrial uses.

- Potential future onsite residents were assumed to have contact with the surface soil and to use groundwater from the Exposition groundwater zones for all domestic needs. Default residential parameters were used.

- The current offsite resident exposure scenario was developed to assess inhalation exposure to chemicals volatilized from subsurface soils and perched groundwater plumes. Residential inhalation exposure parameters were used to evaluate data from indoor and outdoor air samples. This exposure pathway was also evaluated using the

Johnson and Ettinger model to predict potential exposures due to vapor intrusion by volatile chemicals found in shallow soil gas samples.

1.8.2 Toxicity Assessment

The COCs evaluated in the risk assessment were selected using the following criteria:

- Those chemicals detected in greater than 5 percent of the samples analyzed and detected at a maximum concentration that exceeded one-tenth of the USEPA Region IX PRGs were retained as COCs.

- The concentrations of inorganic chemicals in the soil were also screened against the 95 percent upper tolerance limit (95 % UTL) of the background data for California soils (Bradford et al., 1996).

- The exposure point concentration evaluated was either the maximum detected concentration or the 95 percent upper confidence limit (95 % UCL) calculated based on the statistical distribution of the sample concentration values.

Toxicity values (cancer slope factors and references doses) were selected from the following sources. Preference was given to values available on USEPA's Integrated Risk Information System (IRIS) accessible at http://www.epa.gov/IRIS (USEPA, 2002). If no toxicity values were available on IRIS the Health Assessment Summary Tables (HEAST) was searched (USEPA, 1997). If information was not available from these two sources, values used by USEPA Region IX to develop the PRG values were used to assess risks at the Pemaco site (USEPA, 2000). California EPA toxicity values more than 4-fold more conservative than corresponding USEPA values were used to evaluate risks at the Pemaco site (CalEPA, 1996).

1.8.3 Risk Characterization

The only current onsite use of the Pemaco site is by local gangs of adolescents who trespass on the site. Current offsite risks posed by potential inhalation exposure to volatile chemicals in the neighborhood adjacent to the Pemaco site were also evaluated.

Future onsite land-use scenarios include a park user, an excavation worker and residents. The park user scenario represents the most likely future land use as the property is slated for development into the Maywood Riverfront Park. The excavation worker scenario was evaluated to determine if exposure to contaminants in subsurface soil would raise human health concerns (especially during redevelopment activities). Although the planned future land use is as a park, residential use of the property cannot be excluded, because the site is adjacent to a residential community and the City of Maywood may rezone the property for residential development in the future. While actual domestic use of untreated groundwater from the Exposition groundwater zones is unlikely due to the availability of a municipal water supply in the community and due to restrictions on development of private groundwater wells by the Regional Water Quality Control Board (RWQCB), the residential scenario included the use of groundwater to provide a conservative evaluation of all possible risks to human health.

Generally accepted USEPA screening levels for carcinogenic health risks are between 10^{-6} and 10^{-4} and for non-carcinogenic health risks a hazard quotients less than 1.0 is considered to be acceptable. The total estimated carcinogenic risk and noncarcinogenic hazards for each of the five receptor scenarios calculated as part of the Pemaco risk assessment are tabulated below for both RME and CT parameters. The specific chemical risk drivers associated with each media are discussed in the paragraphs that follow and are summarized in Table 1.11.

Receptor	Media	Total Carcinogenic Risk		Total Noncarcinogenic Hazard Quotient	
		RME (1)	CT (2)	RME	CT
Current Onsite					
Trespasser	Surface soil	4.5E-06	4.3E-07	1.0E-02	2.2E-03
Future Onsite					
Park User	Surface soil	7.9E-05	1.9E-05	3.1E-01	1.2E-01
Excavation Worker	Surface and subsurface soil	6.9E-06	8.5E-07	1.2E-01	2.5E-02
Resident	Surface soil, groundwater, and vapor intrusion	1.6E-01	4.5E-02	1.8E+03	7.5E+02
Current Offsite					
Resident	Indoor/Outdoor air	9.2E-05	2.3E-05	1.1E+01	7.1E+00
	Outdoor air background	3.7E-05	NA	4.4E+00	NA
	Modeled vapor intrusion	1.6E-05	3.1E-6	1.0E-02	5.5E-03

(1) Reasonable maximum exposure parameters

(2) Central tendency exposure parameters

Under current land-use conditions, when the only use of the site is by occasional trespassers, the estimated carcinogenic risks using RME parameters falls at the lower end of the USEPA target risk range of 1E-06 to 1E-04. The carcinogenic risk was primarily due to potential exposure to benzo(a)pyrene and dibenzo(a,h)anthracene by the ingestion and dermal exposure routes. Using CT parameters, the carcinogenic risk for the Trespasser was below the target range. The total noncarcinogenic hazard index was well below the target level of 1.0, thus indicating that noncarcinogenic adverse effects to human health would be unlikely.

The estimated carcinogenic risks using the future park user scenario with either the RME or CT parameters falls in the middle of the USEPA target risk range (see above table). The carcinogenic risk was primarily due to potential exposure to benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene by the ingestion and dermal exposure routes. The total noncarcinogenic hazard index was well below the target level of 1.0, thus indicating that noncarcinogenic adverse effects to human health would be unlikely.

The estimated carcinogenic risks using the future excavation worker scenario with RME parameters falls in the lower end of the USEPA target risk range and falls below the target range using CT parameters (see above table). The carcinogenic risk was primarily due to potential exposure to arsenic, benzo(a)pyrene, and dibenzo(a,h)anthracene by the ingestion exposure route. The total noncarcinogenic hazard index was well below the target level of 1.0, thus indicating that noncarcinogenic adverse effects to human health would be unlikely.

The estimated carcinogenic risks using the future onsite resident exposure scenario, with either RME or CT parameters, falls well above the upper end of the USEPA target risk range (see above table). The estimated carcinogenic risks were primarily due exposure to contaminants in the Exposition groundwater zones. The estimated carcinogenic risks were greatest for inhalation exposure, but also exceeded the upper end of the USEPA target risk range due to ingestion and dermal exposure. The carcinogenic risk was primarily due to potential exposure to arsenic, benzene, chloroform, TCE, and vinyl chloride. The total noncarcinogenic hazard index also greatly exceeded the target level of 1.0, thus indicating that noncarcinogenic adverse effects to human health would be possible. The elevated noncarcinogenic hazard index was primarily due to potential exposure to acetone, arsenic, benzene, chloroform, cis-1,2-dichloroethene, manganese, TCE, and vinyl chloride.

The estimated carcinogenic risks based on measured indoor and outdoor air concentrations, using the current offsite resident exposure scenario falls within the target risk range using either RME or CT exposure parameters (see above table). The carcinogenic risk was primarily due to potential exposure to chloroform, benzene, methyl tert-butyl ether, and tetrachloroethene. The total noncarcinogenic hazard index also exceeded the target level of 1.0 with either RME or CT parameters, thus indicating that noncarcinogenic adverse effects to human health would be possible. The elevated noncarcinogenic hazard index was primarily due to potential exposure to chloroform, 1,2,4-trimethylbenzene, and benzene. Risk estimates, based on background air sample data, also resulted in carcinogenic estimates within the USEPA target risk range and the noncarcinogenic hazard quotient also exceeded the target level of 1.0 using RME parameters. Thus, the site-related risks may lie within the level of background risk, but more background data is needed to establish an adequate statistical basis for comparison.

Estimates of carcinogenic risk based on vapor intrusion modeling from maximum observed shallow soil gas concentrations also gave estimates of cancer risk within the USEPA target range, but the noncancer hazard estimate was well below the threshold level of 1.0. The greatest potential cancer risk was due to exposure to trichloroethene. The indoor air vapor intrusion pathway is of minimal concern at the Pemaco site, based on the results of the Johnson-Ettinger model (USEPA, 2000c).

These estimation results are interpreted in relation to the Superfund site remediation goals in the NCP. The cancer risk remediation goals are an excess lifetime cancer risk (ELCR) range from 10^{-6} to 10^{-4}. Results for ELCR below 10^{-6} suggest that the increased risk of developing cancer in a lifetime due to exposure to the COCs is very small and that no further remedial action is required. Results for ELCR that fall in the range of 10^{-6} to 10^{-4} suggest that additional investigation may be needed to further evaluate the risks. Results for ELCR in excess of 10^{-4} indicate that increased cancer risk due to exposure to the COC may warrant some type of remedial action.

Risk-based values, or remediation goal options, were developed during the Pemaco risk assessment for all risk drivers summarized by receptor above. These goals are calculated by rearranging the equations used to calculate each COCs hazard quotient or incremental cancer risk so that the equations can be used to solve for a concentration that will result in target hazard indexes of 1.0 or target cancer risk of 1E-06. Remediation goal options for each risk driver are provided in Table 1.11.

1.9 Estimation of Volume and Concentration of Contaminated Media

The volume, location, and composition of contaminated soil and groundwater above Federal and California Primary MCLs and/or USEPA Region IX PRGs for the COPCs were estimated using data from the RI (TN&A, 2002a). These estimates provide the basis for the development, screening, and analysis of remedial technologies and assembled remedial alternatives to be discussed in Sections 2.5, 2.6, 3.0, and 4.0. Detailed volume calculations are presented in Tables 1.12 and 1.13.

It should be noted that all groundwater (and subsequent upper and lower vadose zone soil) calculations are based January 2002 analytical data. Due to the consistency of data from subsequent quarterly sampling events, the area and volume of contamination is not expected to vary significantly. Concentration versus time graphs (Graphs 1 through 3) are available to illustrate the relatively stabile COC concentrations in Site wells, taking into account variations caused by seasonal fluctuations in groundwater.

1.9.1 Surface and Near-surface Soil

Consistent with the fact that clean fill was placed over much of the central portion of the site during previous removal actions, the majority of metals and SVOCs soil contamination within surface and near-surface soils appears to lie along the periphery of the Pemaco site and railroad right-of-way (Figure 10). For the purpose of volume calculation, surface soils were deemed zero to 1-foot bgs and near-surface soils were deemed 1-ft to 3-ft bgs. Thirty-six grids indicated metal and/or SVOC contamination in surface soils. Thirty grids indicated metal and/or SVOC contamination in near-surface soils; of these, fifteen grids indicated contamination in near-surface soils below “clean” surface soils. Table 1.14 summarizes each grid volume for which metals and/or SVOC concentrations exceeded cleanup criteria. Volumes of contaminated surface and near-surface soils at the Pemaco site are as follows:

- 69 cubic yards (metals in surface soils),
- 787 cubic yards (SVOCs in surface soils),
- **833 cubic yards** (total volume of contaminated surface soils – overlap of grids contaminated with metals and SVOCs considered),
- 93 cubic yards (metals in near-surface soils),
- 1,340 cubic yards (SVOCs in near-surface soils), and
- **1,390 cubic yards** (total volume of contaminated near-surface soils – overlap of grids contaminated with metals and SVOCs considered).
- **2,220 cubic yards (total volume of contaminated surface and near-surface soils).**

The above near-surface soil volumes were calculated independent of surface soil volumes because at this point in the FS process, the objective is to determine contaminated volumes of each media irrelevant of remedial actions.

1.9.2 Upper Vadose Zone Soil

Analytical results of upper vadose zone soils (approximately 3 to 35 ft bgs) indicate occurrence of eleven VOCs, seven SVOCs, two metals and one solvent at concentrations that exceed Region IX DAF 20 SSLs. With exception to VOC contamination, all constituents that exceeded SSLs, could be attributed to sources other than past industrial practices at the Pemaco site. For example, metal concentrations above SSLs were limited to offsite locations, likely background; SVOCs exceeding SSLs (all PAHs) were limited to soils above 6 ft bgs, considered part of the PAH surficial phenomenon discussed in Section 1.6.1, and the solvent “hit” (acetone) can be attributed to bentonite pellets used during well installation. For this reason, only the average concentration of VOCs, 6,600 µg/kg, in upper vadose zone soils was calculated. Table 1.15 tabulates the calculation of average VOCs in upper vadose zone soil samples collected during the RI.

Approximately 145,000 cubic yards of VOC-contaminated upper vadose zone soil exists within the Pemaco boundary and adjacent properties. (Only an estimated 82,500 cubic yards exists within the Pemaco property boundary alone.) For the purpose of volume calculation, contamination was assumed to exist throughout the entire upper vadose zone thickness (3 ft to 35 ft bgs) throughout the aereal extent of the soil horizon (Figure 11A). Table 1.12 summarizes the volume calculation for upper vadose zone soils where discrete soil sample concentrations exceed cleanup criteria.

1.9.3 Lower Vadose Zone Soil

Analytical results of lower vadose zone soils (approximately 35 to 65 feet bgs) indicate concentrations of six VOCs and one metal that exceed Region IX DAF 20 SSLs. The concentrations of five VOCs and six metals exceeded DAF 1 SSLs in samples collected from a depth of 50 ft or greater. The widespread presence of metals within lower vadose zone soils suggests that these metals are likely background and not from a Pemaco release. For this reason, only the average concentration of VOCs in lower vadose zone soils, 9,400 µg/kg, was calculated. Table 1.16 tabulates the calculation of average VOCs in lower vadose zone soil samples collected during the RI.

Approximately 15,400 cubic yards of VOC-contaminated lower vadose zone soil exists within the Pemaco boundary and adjacent properties. (Only 14,100 cubic yards exists within the Pemaco property boundary alone.) For the purpose of volume calculation, contamination was assumed to exist throughout the entire lower vadose zone thickness (35 to 65 ft bgs) of the aereal extent of the horizon (Figure 11B). Table 1.12 summarizes the volume calculation for lower vadose zone soils where discrete soil sample concentrations exceed cleanup criteria.

1.9.4 Perched Groundwater

Analytical results from two *in-situ* groundwater sampling events and 8 quarterly groundwater monitoring events (to date), have enabled the characterization and delineation of perched zone groundwater contamination. Analytical results were screened against site cleanup criteria for groundwater (State of California and Federal USEPA MCLs for drinking water USEPA Region IX Tap Water PRGs).

As discussed in Section 1.6.4, the most prevalent and widespread contaminants within the perched groundwater are chlorinated VOCs, although several “hot spots” of non-chlorinated VOCs (BTEX) are present within the perched groundwater zone. Figure 14 illustrates a composite plume of the PCE, TCE, and VC plumes, as well as the above-described BTEX “hot spots”. The average concentration of VOCs within the perched groundwater zone, 469 µg/L, was calculated utilizing select wells representative of the entire plume surface area. Table 1.17 tabulates the calculation of average VOCs for detected analytical results within the perched groundwater zone.

For the purpose of volume calculations, the average aquifer plume thickness (2.58 ft thick) and average porosity values 0.43 (unit less) were determined. Table 1.13 illustrates volume calculations for the individual VOC plumes (PCE, TCE, and VC) and the composite perched zone plume. The area and volume of contaminated perched zone groundwater at the Pemaco site and adjacent properties are as follows:

- 79,400 sq ft, 658,000 gallons (PCE plume),
- 140,000 sq ft, 1,159,000 gallons (TCE plume),
- 52,500 sq ft, 435,000 gallons (VC plume), and
- **168,000 sq ft**, 1,394,000 gallons (entire composite VOC plume).

1.9.5 Exposition Zone Groundwater

Analytical results from two *in-situ* CPT groundwater sampling events and 8 quarterly groundwater monitoring events (to date), have enabled the characterization and delineation of the upper Exposition Aquifer contamination. Analytical results were screened against site cleanup criteria for groundwater (State of California and Federal USEPA MCLs for drinking water USEPA Region IX Tap Water PRGs).

Approximately 15,600,000 gallons of VOC-contaminated groundwater exists within the ‘A’ and ‘B’ Zones in the Pemaco area. This estimate is based on a 552,000 sq ft area, which includes an overlay of both the ‘A’ and ‘B’ Zone TCE plumes. Figure 15 illustrates the composite TCE plume. TCE was selected to represent maximum contamination within the ‘A’ and ‘B’ Zones, as TCE is the most concentrated and widely dispersed VOC within these zones. The average concentration of VOCs within the Exposition groundwater zone was calculated utilizing select wells representative of the composite ‘A’ and ‘B’ Zone source area (16,700 µg/L –10,000 µg/L-contour of plume), composite ‘A’ and ‘B’ Zone area within the 1,000 µg/L-contour of plume (13,000 µg/L-contour of plume), and the entire ‘A’ and ‘B’ Zone plume area (4,600 µg/L – 5.0 µg/L-contour of plume). Tables 1.18A through 1.18C tabulate the calculation of average VOCs within the Exposition groundwater zones.

For the purpose of volume calculations, the average aquifer plume thickness for the ‘A’ (3.20 ft thick) and ‘B’ (3.73 ft thick) Zones were determined. Likewise, the average porosity values of the ‘A’ and ‘B’ zone (0.568 and 0.519, respectively) were determined. For the ‘A’ and ‘B’ Zone composite plume, the sum of the ‘A’ and ‘B’ Zone thicknesses was calculated (6.93 ft thick) and an average porosity value (0.544) was determined. Table 1.13 illustrates volume calculations for the individual ‘A’ and ‘B’ Zone plumes as well as the composite Exposition ‘A’ and ‘B’ plume.

Area and volume of TCE-contaminated Exposition groundwater within the Pemaco area are as follows:

- 353,000 sq ft, 4,792,000 gallons (‘A’ Zone – greater than 1.0 ppb);
- 56, 900 sq ft, 774,000 gallons (‘A’ Zone – greater than 1,000 ppb);
- 9,940 sq ft, 138,000 gallons (‘A’ Zone – greater than 10,000 ppb);
- 771,000 sq ft, 11,167,000 gallons (‘B’ Zone – greater than 1.0 ppb);
- 67,800 sq ft, 983,000 gallons (‘B’ Zone – greater than 1,000 ppb);
- 5,580 sq ft, 79,558 gallons (‘B’ Zone – greater than 10,000 ppb);
- **552,000 sq ft**, 15,561,000 gallons (‘A’ and ‘B’ Zone – greater than 5 ppb);
- **69,400 sq ft**, 1,954,000 gallons (‘A’ and ‘B’ Zone – greater than 1,000 ppb); and
- **10,700 sq ft**, 301,630 gallons (‘A’ and ‘B’ Zone – greater than 10,000 ppb).

2.0 IDENTIFICATION AND SCREENING OF TECHNOLOGIES

2.1 Introduction

This chapter discusses the development and screening of the technologies and process options used to assemble the remedial alternatives for the Pemaco site. The steps involved in this screening include:

- Developing media-specific remedial action objectives (RAOs)
- Developing media-specific general response actions
- Identifying and screening remedial technologies and process options within each general response action based on technical feasibility
- Screening remedial technologies and process options within each technology based on technical implementability, effectiveness, and cost.

The Pemaco site has five media of concern: (1) surface and near-surface soil, (2) upper vadose zone soil, (3) lower vadose zone soil, (4) perched groundwater, and (5) Exposition Zone groundwater. RAOs and general response actions were identified for each medium. The following sections discuss the development of the RAOs, general response actions, and the process of developing and screening technologies and process options.

2.2 Remedial Action Objectives

2.2.1 Definition

RAOs consist of medium-specific or operable unit-specific objectives for protecting human health and the environment. Specific guidance on developing RAOs is contained in Part 300.430(e) of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). The main goal of the objectives is to prevent exposure to contaminants in excess of public health or environmental standards.

Pemaco RAOs specify the environmental media and contaminants of concern (COCs), exposure routes and potential receptors, and preliminary remediation goals. RAOs for the protection of the environment include the protection of future uses of natural resources (e.g., groundwater). Site RAOs were then used to develop a range of remedial alternatives intended to reduce receptor exposure to contaminated media.

RAOs for each of the five mediums at Pemaco are summarized on the following page and in Table 2.0.

Environmental Media	Remedial Action Objectives
Surface and Near-surface Soils	▪ Prevent risk of human exposure (residents, park users, future construction workers) by direct contact (via inhalation, ingestion, or dermal contact) with soils having (1) carcinogenic COCs in excess of ARARs/TBCs, (2) a total excess cancer risk for all contaminants of greater than 10E-4 to 10E-6 and, (3) a non-carcinogenic threshold value greater than 1.0. ▪ Prevent migration of COCs to the perched groundwater at a rate that would cause groundwater to exceed ARARs/TBCs*.
Upper Vadose Zone Soil	▪ Prevent risk of human exposure (future construction workers) by direct contact (via inhalation, ingestion, or dermal contact) with soils having (1) carcinogenic COCs in excess of ARARs/TBCs, (2) a total excess cancer risk for all contaminants of greater than 10E-4 to 10E-6 and, (3) a non-carcinogenic threshold value greater than 1.0. ▪ Prevent migration of COCs to the perched groundwater at a rate that would cause groundwater to exceed ARARs/TBCs. ▪ Prevent further offsite migration of COCs onto adjacent properties.
Perched Groundwater	▪ Prevent risk of residential human exposure by direct contact (via inhalation (steam), ingestion, or dermal contact) with groundwater having (1) carcinogenic COCs in excess of ARARs/TBCs, (2) a total excess cancer risk for all contaminants of greater than 10E-4 to 10E-6 and, (3) a non-carcinogenic threshold value greater than 1.0. ▪ Prevent further offsite migration of COCs onto adjacent properties. ▪ Prevent migration of COCs to the Exposition groundwater zones at rates that would cause groundwater to exceed ARARs/TBCs. ▪ Restore groundwater quality in perched groundwater zone to ARARs/TBCs or to local background groundwater quality.
Lower Vadose Zone Soil	▪ Prevent migration of COCs to the Exposition groundwater zones at rates that would cause groundwater to exceed ARARs/TBCs.
Exposition Groundwater Zones	▪ Prevent risk of residential human exposure by direct contact (via inhalation (steam), ingestion, or dermal contact) with groundwater having (1) carcinogenic COCs in excess of ARARs/TBCs, (2) a total excess cancer risk for all contaminants of greater than 10E-4 to 10E-6 and, (3) a non-carcinogenic threshold value greater than 1.0. ▪ Minimize further migration of COCs. ▪ Prevent migration of COCs to local production wells (see Figure 6). ▪ Prevent migration of COCs to deeper Exposition groundwater zones at rates that would cause groundwater to exceed ARARs/TBCs in those zones. ▪ Restore groundwater quality in Exposition Zones 'A' and 'B' to ARARs/TBCs or to local background groundwater quality.

* TBCs = 'To Be Considered' documents (see Section 2.2.2).

2.2.2 Approach

Initially, TN&A identified "raw" preliminary remediation goals (ARARs/TBCs – see Section 2.3) as a basis for comparison of analytical data collected during RI activities. This led to the selection of COCs for each of the five media zones present at Pemaco (Tables 1.7C through 1.7H). For this report, it is assumed that the environmental media and COCs identified in the RI report encompass all media and chemicals that require consideration in this FS.

It should be noted that while ambient air is a media with known COCs (Table 1.7A), data indicates that many of the VOCs found in breathing zone air could be due to background conditions of the Los Angeles basin. COCs in soil vapor (Table 1.7B) will be addressed through remediation of subsurface soils and groundwater.

Guidance published in the preamble of the NCP states that preliminary remediation goals associated with RAOs should be based on readily available environmental or health-based chemical-specific Applicable or Relevant and Appropriate Requirements (ARARs), ambient water quality criteria, and other criteria, advisories, or guidance (see Section 2.3). For those chemicals lacking ARARs, other criteria to be considered (TBCs) were utilized, primarily the USEPA Region IX Preliminary Remediation Goals (PRGs).

As not to confuse USEPA Region IX PRGs with site preliminary remediation goals, TN&A has termed goals associated with Pemaco preliminary site-specific remediation goals (PSSRGs). This nomenclature will be utilized from this point forward.

PSSRGs are not only dependent on the identification of ARARs/TBCs, but also on the baseline risk assessment process because a major objective of the goals is to protect human health to a cancer risk range of 10^{-6} to 10^{-4} for carcinogens and to meet a threshold dose limit for noncarcinogenic chemical toxicants. Hence, the "raw" PSSRGs were modified, as necessary, based on results of the baseline risk assessment (e.g., exposure pathway identification, land use assumptions, and institutional controls), which is discussed in more detail in the following paragraphs.

As part of the baseline risk assessment, compounds that consistently exceeded ARAR/TBCs within each media zone were screened in relation to potential human exposure. Only those chemicals likely to make a significant contribution to human health risk/hazard were carried forward into the risk characterization phase of the risk assessment. Chemicals retained by the screens were those chemicals detected at greater than 5% frequency that exceeded their regional background concentrations (where applicable) and statutory values or risk-based guidelines.

Exposure to these COCs by ingestion, inhalation, and dermal exposure routes was evaluated for all media and receptors based on five exposure models consisting of: (1) a current trespasser model, (2) a future park user model, (3) a future excavation worker model, (4) a future onsite residential exposure model, and (5) a current offsite residential model. The models determine what concentration in an environmental medium would result in the maximum potential intake that is not expected to have a significant impact upon human health. These intake levels were established based either on an acceptable incremental cancer risk for potential carcinogens or on an intake level that is within acceptable levels for noncarcinogens.

Each exposure scenario was evaluated for both RME and CT exposure parameters for each of the five exposure scenarios as bulleted below.

- The trespasser scenario was developed using exposure parameters representative of the frequency and duration of adolescent gangs per consultation with the City of Maywood, local police, and church groups.

- For the future park user scenario, outdoor athletic activities are likely to be the most intensive use of the park. Because the residential neighborhood near Pemaco is predominately Latin American and soccer in an intrinsic part of the Latin American culture, playing soccer was selected as an activity representative of the RME conditions. Because the Pemaco site is adjacent to a residential community, residential exposure duration parameters were applied. It was also assumed that the park would be accessible to small children.

- Trespassers and park users are expected to have contact only with the surface soil. In contrast, an excavation worker scenario was evaluated for potential risks due to exposure to subsurface soils up to a depth of 15 feet. Although an excavation worker may only spend a few days or weeks on the Pemaco site, exposure over a career was evaluated. This reflects the potential that an excavation worker in a metropolitan area such as Los Angeles may frequently excavate on properties that are being redeveloped after previous industrial uses.

- Potential future onsite residents were assumed to have contact with the surface soil and to use groundwater from the Exposition groundwater zones for all domestic needs. Default residential parameters were used.

- The current offsite resident exposure scenario was developed to assess inhalation exposure to chemicals volatilized from subsurface soils and perched groundwater plumes. Residential inhalation exposure parameters were used to evaluate data from indoor and outdoor air samples. This exposure pathway was also evaluated using the Johnson and Ettinger model to predict potential exposures due to vapor intrusion by volatile chemicals found in shallow soil gas samples.

A total estimated carcinogenic risk and noncarcinogenic hazard for each of the five receptor scenarios were calculated as part of the Pemaco baseline risk assessment. These risk/hazard totals consist of a compilation of exposure totals for all COCs applicable to the media exposure pathway. The risks/hazards for each COC were compared to the generally accepted USEPA screening levels for carcinogenic health risks (between 10^{-6} and 10^{-4}) and for non-carcinogenic health risks (a hazard quotients less than 1.0). Those chemicals that posed the greatest potential carcinogenic and/or noncarcinogenic risk due to potential exposure for each scenario are considered risk drivers. TBCs for the risk drivers, or remediation goal options, were generated as part baseline risk assessment. These goals are calculated by rearranging the equations used to calculate each COC's hazard quotient or incremental cancer risk so that the equations can be used to solve for a concentration that will result in target hazard indexes of 1.0 or target cancer risk of 1E-06. Remediation goal options for each risk driver were compared to ARARs and other TBCs for selection as PSSRGs for each applicable media zone, as discussed below.

Previously determined 10^{-6} cancer risk levels based on both a residential exposure model and an excavation worker exposure model were identified for all COCs in surface and subsurface soils to 15 ft bgs as part of the Maywood Riverfront Park (MRPP) Risk Assessment (TN&A, 2002d). Additional site-specific remediation goal options for surface soils were determined as part of the Pemaco baseline risk assessment based on the current trespasser exposure model, the future park user exposure model, the future excavation worker exposure model, and the future onsite residential exposure model. The 10^{-6} cancer risk levels and recommended remediation goal options established during both risk assessments were compared to other TBCs (Region IX PRGs for residential soil) for selection as PSSRGs for surface/near-surface soils and subsurface soils to 15 ft bgs. The more conservative values were selected as PSSRGs.

Site-specific remediation goal options for subsurface soils greater than 15 ft bgs are currently being developed based on the future onsite residential exposure model (as a threat to groundwater). Chemical-specific TBCs for subsurface soils (Region IX Soil Screening Levels or SSLs) greater than 15 ft bgs will temporarily serve as PSSRGs for subsurface soils 15 ft to approximately 100 ft bgs until the site-specific remediation goal options are developed and compared to TBCs. Chemical-specific TBCs for subsurface soils, or Region IX SSLs, were developed based on several assumptions for the migration of groundwater pathway including that of an unconfined, unconsolidated aquifer with homogeneous and isotropic hydrologic properties, typically using average leachate values. Site-specific remediation goal options for subsurface soils will incorporate site-specific soil characteristics and leachate values to develop maximum acceptable concentrations for subsurface soils as a threat to groundwater (i.e., what concentration (by analyte) at any specified depth will allow nearby groundwater concentrations to remain below regulatory levels). It is anticipated that the newly developed remediation goal options calculated at the 10^{-6} cancer risk level will not vary much from the established chemical-specific TBCs for subsurface soils (USEPA Region IX SSLs). The more conservative values (between TBCs and remediation goal options) will be selected as PSSRGs.

Another set of site-specific remediation goal options for subsurface soils above the perching clay or 3-35 ft bgs are currently being developed based on the current offsite residential exposure model (as a threat caused by soil vapor intrusion). Site-specific remediation goal options are to be calculated at the 10^{-6} cancer risk level and will be compared to other TBCs for selection as PSSRGs for subsurface soils 3 to 35 ft bgs. The most conservative values will be selected as PSSRGs for these soils.

Site-specific remediation goal options for all COCs in the perched groundwater zone were determined based on the current offsite residential exposure model (as a threat caused by soil vapor intrusion). Site-specific remediation goal options for all COCs in the Exposition ‘A’ and ‘B’ groundwater zones were determined based on the future onsite residential exposure model (assume domestic well installation). Site-specific remediation goal options for both groundwater zones were calculated at the 10^{-6} cancer risk level and were compared to ARARs (Federal and State MCLs) for selection as PSSRGs for both the perched and Exposition groundwater zones, respectively. The more conservative values were selected as PSSRGs for groundwater.

Pemaco PSSRGs are presented in Table 2.1. The following was considered during the development of PSSRGs for Pemaco:

(a) Applicable or relevant and appropriate requirements (ARARs) under federal environmental or state environmental laws, if available;

(b) To be considered documents (TBCs) under federal environmental or state environmental laws, if no ARAR available;

(c) For systemic toxicants, acceptable exposure levels shall represent concentration levels to which the human population, including sensitive subgroups, may be exposed without adverse effect during a lifetime or part of a lifetime, incorporating an adequate margin of safety;

(d) For known or suspected carcinogens, acceptable exposure levels are generally concentration levels that represent and excess upper bound lifetime cancer risk to an individual of between 10^{-4} and 10^{-6} using information on the relationship between dose and response. The 10^{-6} risk level shall be used as the point of departure for determining RAOs for alternatives when ARARs are not available or are not sufficiently protective because of the presence of multiple contaminants at a site or multiple pathways of exposure;

(e) Water quality criteria established under sections 303 or 304 of the Clean Water Act shall be attained where relevant and appropriate under the circumstances of the release;

(f) Water quality criteria established under State of California's SWRCB Resolution 68-16 antidegradation policy shall be followed to the maximum extent possible;

(g) An alternate concentration limit (ACL) may be established in accordance with CERCLA section 121(d)(2)(B)(ii).

2.3 Applicable or Relevant and Appropriate Requirements

Under CERCLA, a remedial action, upon completion, must meet ARARs. ARARs can be defined (a detailed definition is presented in Section 2.3.1) as requirements in promulgated environmental laws as they relate to onsite remedial actions. Onsite includes the aereal extent of contamination and all suitable areas in proximity to the contamination necessary for implementation of the response action at the Site (40 CFR 300.5). Offsite actions are not addressed through this ARARs SCREENINGand must comply with all applicable local, state, and federal administrative and substantive requirements.

In some situations, ARARs may not be available or adequately address protection of human health and the environment. Where ARARs do not sufficiently address a situation, to-be-considered (TBC) documents (e.g., nonpromulgated advisories, criteria, guidance, or proposed standards) issued by federal and state agencies were identified (40 CFR 300.400.g.3). These TBC documents are not enforceable nor are they legally binding and do not have the same status as ARARs. However, guidance documents are considered when developing cleanup levels and evaluating risks to human health or the environment.

These ARARs and TBC documents, in conjunction with the overall protection to human health and the environment criterion, form the threshold criteria (i.e., threshold, primary balancing, and modifying criteria) to evaluate remedial alternatives and meet when selecting a remedial action. The ARARs and TBCs identified during the RI/FS are preliminary. The final determination of ARARs will not be made until the remedy for the Pemaco Site is selected and documented in the decision documents, including the Proposed Plan and the Record of Decision (ROD).

To document all the potential ARARs and TBCs, a comprehensive tabular summary of ARARs and TBCs applied to the Site is provided in Table 2.2.

2.3.1 ARARs Definition

ARARs are defined in the CERCLA to include:

- Any standard, requirement, criterion, or limitation under federal environmental law.
- Any promulgated standard, requirement, criterion, or limitation under a state environmental or facility-siting law that is more stringent than the associated federal standard, requirement, criterion, or limitation.

An ARAR may be either “applicable,” or “relevant and appropriate.” These terms are defined in the National Oil and Hazardous Substance Contingency Plan (referred to as the National Contingency Plan [NCP]) (40 CFR §300.5) to include:

- Applicable requirements are those cleanup standards, standards of control, or other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state environmental or facility, citing laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at the site.
- Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state environmental or facility, citing laws that are not “applicable” to the site but address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site.

The potential ARARs in this document represent the most stringent of the state and federal requirements. When considering the substantive state requirement for the Site, only those promulgated state requirements that are identified by the state in a timely manner and that are more stringent than federal requirements are considered ARARs (CERCLA §121(d)(2)(A)(ii)).)

The timing and stringency criteria are applied to the state requirements prior to identification as potential ARARs in this document. For example, the state identified the California Environmental Quality Act (CEQA) as an ARAR (SWRCB, 1992; RWQCB, 2002). CEQA is an informational document used by California public agencies in the decision making process with requirements that are no more stringent than the environmental review conducted through CERCLA. Prescribed CERCLA procedures for evaluating environmental impacts include selecting remedial action with feasible mitigation measures, providing for public participation and review, and evaluating short- and long-term impacts to human health, procedures that are substantially equivalent to the CEQA requirements. Because the state and federal requirements through CERCLA are no less stringent than CEQA requirements, EPA has determined that CEQA is not an ARAR. The state agencies have published or provided state requirements relevant to their agency jurisdiction (SWRCB, 1992; RWQCB, 2002; CDFG, 2002).

Non-environmental laws, such as worker safety laws, are not ARARs, but are complied with to the extent that they are applicable. Additionally, any offsite activity must comply with all applicable substantive and administrative regulatory requirements.

2.3.2 ARAR Waiver Provisions

Specific circumstances in which ARARs may be legally waived are established in the NCP 40CFR300.430 (f)(1)(ii)(c). There are six waiver criteria available, including interim measures, greater risk to health and the environment, technical impracticability, equivalent standard of performance, inconsistent application of state requirements, and fund balancing. The criteria and circumstances in which a waiver may be applied are:

- Interim Measure—The remedial action selected is only a part of the total remedial action that will attain such level or standard of control when completed.
- Greater Risk to Health and the Environment—Compliance with the requirement will result in greater risk to human health and the environment than alternative operations.
- Technical Impracticability—Compliance with the requirement is technically impracticable from an engineering perspective.
- Equivalent Standard of Performance—The remedial action selected will attain a standard of performance that is equivalent to that required under alternative applicable standards, requirements, criteria, or limitations, through use of another remedial action.
- Inconsistent Application of State Requirements—With respect to state standards, requirements, criteria, or limitations, the state has not consistently applied (or demonstrated the intention to consistently apply) the standard, requirement, criterion or limitation in similar circumstances at other remedial actions within the state.
- Fund Balancing—In case of a remedial action to be undertaken solely under CERCLA §104 using the Fund, selection of a remedial action that attains such level or standards of control will not provide a balance between the need for protection of public health and welfare and the environment at the facility under consideration, taking into consideration the relative immediacy of such threats.

2.3.3 Types of ARARs

USEPA divides ARARs into three categories: chemical-specific, location-specific, and action-specific. Chemical-specific requirements define chemical concentrations required to comply with applicable rules. Potential chemical-specific ARAR limits that must be met for specific contaminants within the groundwater and surface and subsurface soils are also referred to as cleanup standards or levels, discharge criteria, or action limits. All these terms are synonymous with the potential ARAR limits. Location-specific requirements are restrictions placed on the concentration of hazardous substances or in the conduction of activities because they occur in sensitive locations such as wetlands. Action-specific requirements are controls or restrictions for particular treatment, storage, and disposal activities related to the management of hazardous waste.

Potential ARARs for the Pemaco Site are summarized below and tabulated in Table 2.2.

2.3.4 To Be Considered Documents

A large number of state and federal criteria, advisories, and guidance documents are used in the development of the baseline risk assessment. For the sake of brevity and eliminating redundancy in documenting TBCs, the human health and ecological risk assessment guidance documents and health advisories are referenced in the baseline risk assessment document for the Pemaco Site and are not identified as TBCs in this section. The TBC documents presented are intended to address the state and federal guidance documents not associated with risk assessments.

- California Well Standards Bulletin 74-81; 74-90. Substantive standards for the construction of wells have been published by the State of California. California Well Standards Bulletin 74-81 includes municipal and injection well standards. California Well Standards Bulletin 74-90 amends Bulletin 74-81 and includes monitoring well standards. While these standards have not been promulgated and are therefore not ARARs, the extraction wells for municipal reuse and injection wells at the Site will comply with substantive water well construction standards of Bulletin 74-81 and amendments contained in Bulletin 74-90. These standards include annular sealing material and construction, well casing specification, and disinfection procedures. However, extraction and injection well siting requirements are inappropriate for the Site because the effectiveness of the remedy is dependent upon well locations. These California well standards are TBCs for the Site.

- USEPA Region IX Preliminary Remediation Goals (PRGs) – PRGs are tools for evaluating and cleaning up contaminated sites. They are risk-based concentrations combining exposure information and EPA toxicity data. PRGs should be viewed as Agency guidelines, not legally enforceable standards. PRGs for tap water were used when no MCLs were available. No MCLs are available for soils. For surface and near-surface soils at the Pemaco site, PRGs for Residential Soil were used for comparison. PRGs for subsurface soils are termed Soil Screening Levels (SSLs) and are used to screen subsurface soils as a threat to groundwater. A Dilution Attenuation Factor (DAF) of 20 and 1 are available, DAF 1 being more stringent. DAF 20 PRGs are used when the contaminated soil is not directly adjacent to a drinking water source and dilution of the contaminant is occurring before it reaches the drinking water source. DAF 1 PRGs assume that the contaminated soil is directly adjacent to a drinking water source and no dilution of the contaminant is occurring along the pathway between the source soil and the drinking water source. At Pemaco, subsurface soils to 50 ft were compared to DAF 20 SSLs; subsurface soils greater than 50 ft bgs were compared to DAF 1 SSLs.

- California Action Levels (ALs) – ALs are health based advisory levels established by the California Department of Health Services (DHS) for contaminants that lack primary MCLs. ALs are advisory levels and not enforceable standards. An AL is the concentration of a contaminant in drinking water that is considered not to pose a significant health risk to people ingesting that water on a daily basis. It is calculated using standard risk assessment methods for noncancer and cancer endpoints and typical exposure assumptions, including a 2-liter per day ingestion rate, a 70 kilogram adult body weight, and a 70 year lifetime. Lead and 1,4-dioxane are the only COPCs for the Pemaco Site with California ALs (15 mg/L and 0.003 mg/L, respectively).

- State of California Office of Environmental Health Hazard Assessment (OEHNA) Public Health Goals (PHGs) – PHGs are based on health risk assessments using the most current scientific methods.

2.3.5 Chemical-Specific ARARs

Potential chemical-specific ARARs are health- or risk-based concentration limits, numerical values or methodologies for various environmental media (e.g., groundwater and soil) that establish the acceptable amount or concentration of a chemical that may be found in or discharged to the environment. Chemical-specific requirements are available and are presented in Table 2.3 for the COPCs in groundwater. Chemical-specific ARARs do not exist for soils. Because lower vadose zone soil presents a potential source of continuing groundwater contamination, the chemical-specific requirements for soil emphasizes environmental protection of groundwater. Chemical-specific TBC human health advisories and risk assessment guidance documents addressing the soil contaminants are presented in the Pemaco baseline risk assessment (TN&A, 2002c).

2.3.5.1 Federal Chemical-Specific Requirements

Federal Primary Drinking Water Standards (40 CFR Part 141). Federal primary MCLs under the Safe Drinking Water Act (SDWA) protect the public from contaminants that may be found in drinking water. The NCP defines MCLs as relevant and appropriate for groundwater that is a potential source of drinking water. Although neither the perched or the exposition groundwater are viable aquifers, the San Pedro Aquifers, which are used for municipal and industrial purposes, may lie beneath the site. To prevent potential migration to possible lower aquifers, the selected remedy will use federal MCLs, unless State MCLs are more stringent, as cleanup levels for perched and exposition groundwater. The federal MCLs for the COPCs are presented in Table 2.3.

2.3.5.2 State Chemical-Specific Requirements

Primary Drinking Water Standards (22 CCR §64431 and 64444). California has promulgated drinking water standards for public drinking water sources under the California Safe Drinking Water Act (California Health and Safety Code [H&S Code] §4010 et. seq.). California primary MCLs are established to protect public health from contaminants that may be found in drinking water sources.

Although the perched and upper Exposition groundwater zones below the Site do not qualify as viable aquifers (insufficient yield), there is a potential for contaminant migration to the deeper Exposition zones ('D' and 'E') or deeper aquifer systems of the San Pedro Formation that are used as a municipal and domestic supply. As a conservative measure, applying drinking water standards to the perched and Exposition groundwater zones would be relevant and appropriate as a cleanup level for the groundwater. For some of the chemical constituents, the California MCLs are more stringent than the federal requirements. Only the California MCLs more stringent than the federal MCLs are considered ARARs. The MCLs identified as ARARs for the COPCs are presented in Table 2.3.

Secondary Drinking Water Standards (22 CCR §64471). The California secondary drinking water standards are promulgated state standards applicable to public water system that address the aesthetic characteristics (i.e., taste, odor, appearance) of drinking water.

California Secondary MCLs are enforceable while the federal secondary MCLs are recommendations. Four of the COPCs at the Pemaco Site, aluminum, iron, manganese, and MTBE, are chemicals listed with secondary drinking water standards.

SWRCB Resolution No. 92-49. The Policy and Procedures for Investigation and Cleanup and Abatement of Discharges under Water Code §13304 derives its authority to maintain the highest quality of water (SWRCB Resolution No. 68-16) through waste discharge requirements as implemented through the federal National Pollutant Discharge Elimination System (NPDES) or RWQCB waste management and discharge requirements (27 CCR §20200 et seq.).

The only substantive requirement is identified in SWRCB Resolution No. 92-49, Section III.G. The section requires cleanup either to background water quality, or the best water quality that is reasonable if background cannot be restored. A selected alternative cleanup level greater than chemical background concentration for the aquifer would have to be consistent with maximum benefit to the public, the present and anticipated future beneficial uses, and conform to water quality control plans and policies.

SWRCB Resolution No. 92-49 is also relevant and appropriate for soil at the Site. Attainment of this requirement is consistent with the objective of soil remediation at the Site. Contaminated soil must be remediated to a concentration that does not exhibit a continuing source of contamination to groundwater.

Establishment of organic and inorganic cleanup levels of background at the Site is neither technologically nor economically feasible. To document the infeasibility of establishing background cleanup levels, a technical and economical feasibility analysis (TEFA) is completed as provided in the California regulation establishing concentration limits for nonhazardous waste (27 CCR §20400 et seq.).

California Water Code Section 13240 *et seq*. The Water Quality Control Plan for the Los Angeles Region (Basin Plan, adopted November 19, 1992) contains numerical and narrative water quality objectives for waters of the state that ensure protection of beneficial uses and prevention of nuisances affecting beneficial use. These objectives are not merely restricted to surface water but also apply to groundwater (SWRCB, 1992). Promulgated numerical water quality objectives may be chemical-specific ARARs. Nonpromulgated mechanisms or theories on how to derive a numerical water quality objective or meet a numerical water quality goal may also be ARARs if specific regulations are promulgated implementing the goal (55 FR 8746, March 8, 1990).

The numerical water quality objectives for groundwater supply used as a domestic or municipal supply (MUN) are based on the drinking water standards. Because the primary MCLs have already been identified as ARARs for the COCs at the Site, the numerical water quality objectives in the Basin Plan are addressed through the primary MCLs as chemical-specific ARARs.

Similarly, the RWQCB's narrative water quality objectives for groundwater are addressed through the primary MCLs. The narrative water quality objectives establish that "groundwater shall not contain concentrations of chemical constituents or radionuclides in excess of the limits specified in the following provisions (California drinking water regulations)." Although the perched and Exposition groundwater zones within the vicinity of the site are not used as a drinking water source, it has the potential to impact lower groundwater zones, which are used as a drinking water source. The designated beneficial use is the protection of a MUN, and the numerical primary MCLs have been promulgated and are ARARs.

As a component of some of the remedial alternatives discussed in the FS, discharge options for extracted groundwater are discussed. These alternatives evaluate groundwater discharge options, including municipal stormwater drainage system, aquifer re-injection, and municipal sewer system (i.e., POTW). Groundwater discharge options are considered for evaluation under the action-specific category.

DTSC Hazardous Waste Regulations Hazardous Waste Definition Standards (22 CCR Part 261)

Contaminated soil and groundwater, once extracted for treatment, must be managed as state & federal hazardous waste if such soil or groundwater contains levels of hazardous substances that meet or exceed state and federal hazardous waste toxicity criteria for specific hazardous wastes and/or contains one or more RCRA listed hazardous wastes.

Contaminated media treated to specified cleanup levels will no longer need to be managed as hazardous waste.

2.3.6 Location-Specific ARARs

The potential location-specific ARARs are substantive restrictions placed on the chemical contaminant or the remedial activities based on the Site's geographic or ecological features. Examples of location-specific features include floodplains, seismic faults, wetlands, historic places, and sensitive ecosystems or habitats.

2.3.6.1 Federal Location-Specific Requirements

No federal location-specific ARARs have been identified for the Pemaco Site.

2.3.6.2 State Location-Specific Requirements

California Fish and Game Code § 3503, Protection of Birds' Nests

This law prohibits take, possession, or needless destruction of any bird nests and eggs, except as provided by the Fish and Game Code or regulations.

Selected remedy will not result in a "take" and will comply with this requirement.

California Fish and Game Regulations Non-Game Animals (14 CCR § 472)

Regulation provides that nongame birds and mammals may not be taken expect for English sparrow, starling, coyote, weasels, skunks, opossum, moles and rodents (excludes treed and flying squirrels, and those listed as furbearers, endangered or threatened species), and American crows.

Selected remedy will not result in a "take" and will comply with this requirement.

2.3.7 Action-Specific ARARs

The potential action-specific ARARs are usually technology- or activity-based requirements for remedial activities. The action-specific ARARs presented are intended to address the remedial alternatives being evaluated in the FS that may be applied to the Site.

2.3.7.1 Federal Action-Specific Requirements

NPDES Non-Point Source Discharge (40 CFR § 122.26)

Non-point sources are addressed by using best management practices for control of contaminants to stormwater runoff from construction activities on sites greater than one acre.

All alternatives that evaluate soil excavation for the Pemaco Site are confined to areas less than one acre, so the requirement is not applicable to the site, but is relevant and appropriate.

2.3.7.2 State Action-Specific Requirements

Basin Plan for Los Angeles Region, Chapter 4 - Remediation of Pollution

The Basin Plan recognizes the cleanup goals based on the State's Antidegradation Policy as set forth in State Board Solution No. 68-16 (see below).

SWRCB Resolution No. 68-16. The Statement of Policy With Respect to Maintaining High Quality of Waters in California is the state's antidegradation policy that provides a narrative standard that requires that high quality surface water and groundwater be maintained to the maximum extent possible.

Any waste discharge to existing high quality waters will be required to meet waste discharge requirements which will result in best practical treatment technology, ensuring that a pollution or nuisance will not occur and the highest water quality consistent with maximum benefit to the people of the state will be maintained. Determination is made through a two-step process to determine (1) whether further degradation may be allowed, and (2) the discharge level that will result in the best practicable treatment or control of the discharge.

EPA has determined that Resolution No. 68-16 is not a chemical-specific ARAR for setting aquifer cleanup standards but is applicable to treatment technologies with active discharges to surface water or groundwater. Antidegradation requirements apply prospectively and only obligate EPA to prevent further degradation of the water during and at completion of the cleanup action (EPA, 1990).

Therefore, Resolution No. 68-16 is an action-specific ARAR applicable to remedial alternatives that include surface water discharges, ponding basins, or groundwater re-injection. Groundwater re-injection is a potential option for the disposal of treated groundwater at the Site. EPA's position is that only COPCs identified for the Site shall be treated. Treated groundwater injected within the footprint of a contaminated plume will be treated to at least the concentration level in the groundwater at the point of re-injection, but not greater than the drinking water standard. Re-injection outside the contaminated plume must be less than the MCL standard at which the discharger can be expected to achieve using reasonable control measures at the point of re-injection (EPA, 1993).

California Water Code §13140 - 13147, 13172, 13260, 13263, 132267, 13304 (27 CCR Div.2, Subdiv.1, Chap.3, Subchap.2, Art.2 – Porter-Cologne Water Quality Control Act)

Wastes classified as a threat to water quality (designated waste) may be discharged to a Class I hazardous waste or Class II designated waste management unit. Nonhazardous solid waste may be discharged to a Class I, II, or III waste management unit. Inert waste would not be required to be discharged into an SWRCB-classified waste management unit.

Waste will be classified for disposal to appropriate permitted off-site waste management units. CERCLA waste (e.g. contaminated soil, spent GAC) would be disposed at an off-site disposal facility.

SWRCB Resolution No. 88-63. The SWRCB resolution Sources of Drinking Water specifies, with certain exceptions, all groundwater and surface waters have the beneficial use of municipal or domestic water supply. Since SWRCB Resolutions No. 68-16 and 92-49 focus on the protection of groundwater for beneficial uses, the definition of drinking water sources is an important consideration for this Site. To determine compliance with SWRCB Resolutions No. 68-16 and 92-49, the water quality of the contaminated area and the receiving water is necessary.

For groundwater below the Site, an aquifer would be considered to be suitable or potentially suitable as a municipal or domestic water supply with the exception of water sources that:

- Yield water with the total dissolved solids (TDS) exceeding 3,000 milligrams per liter (mg/L);
- Contain natural or anthropogenic contaminated water that cannot be reasonably treated for domestic use using either Best Management Practices or best economically achievable treatment practices; or
- Are not capable of sustaining 200 gallons per day through a single well.

No samples have been collected and analyzed for TDS from either the perched or Exposition groundwater zones. Estimates from specific conductance field measurements of each of the groundwater zones indicate that the TDS concentrations range from 500 to 1,000 mg/L. General water chemistry concentrations for the perched and Exposition groundwater zones exceed the drinking water standards (MCLs) for iron, chloride, nitrate and sulfate in several of the wells sampled.

The perched zone is not capable of sustaining 200 gallons per day through a single well, but may be contributing to contamination in the underlying groundwater zones. The upper and deeper Exposition Zones could likely sustain 200 gallons per day. Furthermore, there is a potential for contaminants to migrate from the perched and upper Exposition groundwater zones to the deeper Gage/Gardena Aquifer (of the Lakewood Formation) and to the aquifers of the San Pedro Formation. Therefore, SWRCB Resolution No. 88-63 is applicable (i.e., an ARAR) to the Site, and both the perched groundwater zone and the Exposition zones should be treated as a potential source of drinking water for protection under SWRCB Resolutions No. 68-16.

The selected remedy will apply a groundwater cleanup level protective of drinking water.

California Hazardous Waste Laws. On July 26, 1982, the federal Resource Conservation and Recovery Act (RCRA) requirements were promulgated. California received EPA authorization to administer and implement a state hazardous waste management program, which is more stringent than the federal RCRA program. Authorization to enforce the federal requirements is received only after the RCRA requirements are incorporated into California's hazardous waste regulations. Those portions of the RCRA program presented in this report have received authorization by EPA and have been incorporated into the California regulations. The California Hazardous Waste Control Law, Chapter 6.5 of Division 20 of the California H&S Codes, and the regulations of Title 22 CCR are therefore referenced in this report in lieu of the RCRA.

The two methods for characterizing hazardous waste are RCRA-listed (i.e., source and non-source specific) and by characteristics (i.e., ignitability, corrosivity, reactivity, and toxicity). For CERCLA actions that involve treatment, storage, or disposal of hazardous waste after July 26, 1982, the hazardous waste standards will generally be applicable. If federal hazardous waste was treated, stored, or disposed at the Site before the effective date of these standards, the standards would be relevant and appropriate (EPA, 1988).

Pemaco, Inc. operated for approximately 40 years, from the 1950s until 1991, as a chemical blending facility and distributor (E&E, 1998a). Large quantities of chemicals were stored in 55-gallon drums, aboveground storage tanks (ASTs) and in thirty-one 500- to 20,000-gallon underground storage tanks (USTs). A wide variety of chemicals were used onsite including chlorinated and aromatic solvents, flammable liquids, oils and specialty chemicals.

Analytical results of environmental samples collected during the RI indicate that chemicals originating from past industrial practices (spills/leaking drums and tanks) at the Pemaco property have impacted soil and groundwater at the site, as well as offsite, and below adjacent industrial and nearby residential properties. (Adjacent properties have also contributed to offsite VOC-contamination.) VOC-contaminated soil has been detected at concentrations exceeding 400,000 µg/kg; VOC-contaminated groundwater has been detected at concentrations exceeding 20,000 µg/L.

Because the COC concentrations in the soil and groundwater are elevated, the specific hazardous waste requirements may be relevant and appropriate (i.e., an ARAR) to the Site are summarized in the comprehensive tabular summary of ARARs (Table 2.2).

South Coast Air Quality Management District (SCAQMD) Rules and Regulations. To implement the federal Clean Air Act, states are required to submit and adopt a state implementation plan (SIP) for EPA approval. The SIP addresses implementation, maintenance, and enforcement of the national and California ambient air quality standard (AAQS). A significant component of the SIP is the local air pollution district regulations and rules, which are used to control emissions and attain these AAQSs. Federal approval resulted in the SIP being federally enforceable. The SCAQMD rules and regulations addressed in this report were approved by EPA and establish the local air pollution control requirements for Los Angeles County.

- Regulation IV, Rule 402, Nuisance. Discharge from any source shall not contain air contaminants or other material, which causes injury, detriment, nuisance, or annoyance to any considerable number of persons, or to the public. Discharge shall also not endanger the comfort, repose, health or safety of any such persons or the public, or cause injury or damage to business or property. This rule is a potential ARAR.

- Regulation IV, Rule 403, Fugitive Dust. The intention of Rule 403 is to reduce, prevent, or mitigate emission of fugitive dusts from any activity or man-made condition capable of generating fugitive dust. Emissions of fugitive dust shall not remain visible in the atmosphere beyond the property line of the emission source. Activities conducted in the South Coast Air Basin shall use best available control measures to minimize fugitive dust emissions and take necessary steps to prevent the track-out of bulk material onto public paved roadways as a result of their operations. This rule is a potential ARAR.

- Regulation IV, Rule 404, Particulate Matter Concentration. Particulate matter in excess of the concentration standard shall not be discharged from any source. Particulate matter in excess of 450 milligrams per cubic meter (0.196 grain per cubic ft) in discharged gas, calculated as dry gas at standard conditions, shall not be discharged to the atmosphere from any source. This rule is a potential ARAR.

- Regulation IV, Rule 405, Solid Particulate Matter-Weight. Solid particulate matter including lead and lead compounds discharged into the atmosphere from any source shall not exceed the rates provided in Table 450(a) of Rule 405. Nor shall solid particulate matter including lead and lead compounds in excess of 0.23 kilogram (0.5 pound) per 907 kilograms (2,000 pounds) or process weight be discharged to the atmosphere. Emissions shall be averaged over one complete cycle of operation or one hour, whichever is the lesser time period. This rule is a potential ARAR.

- Regulation XI, Rule 1166, Volatile Organic Compound Emissions from Decontamination of Soil. The purpose of Rule 1166 is to control the emission of VOCs from excavating, grading, handling, and treating VOC-contaminated soil. If excavated soil is measured in the field at 50 parts per million using an OVA at less than 1-inch distance from the excavated soil. Rule 1166 is an applicable ARAR if soil excavation of upper vadose zone soils is selected as part of the final remedy for the Site.

- Regulation XIII, Rule 1303, New Source Review. Construction for any relocation or for any new or modified source, which results in an emission increase of any nonattainment air contaminant, any ozone-depleting compound, or ammonia, must include Best Available Control Technology (BACT) for the new or relocated source or for the actual modification to an existing source. This requirement would apply to treatment technologies with potential to emit primary pollutant(s) to the atmosphere.

- Regulation XIV, Rule 1401, New Source of Toxic Air Contaminants. Construction or reconstruction of a major stationary source emitting hazardous air pollutants shall be constructed with Best Available Control Technology for Toxics (T-BACT) and complies with all other applicable requirements. This rule is a potential ARAR.

2.4 General Response Actions

General response actions describe actions that could satisfy the RAOs. General response actions may include no action, institutional actions, containment, removal, disposal, treatment, or a combination of these. The relationship of the general response actions to the RAOs is shown in Figure 16.

2.4.1 No action

The no action alternative is retained throughout the FS process as required by 40 CFR 300.430(3)(6). This provides a comparative baseline against which other alternatives can be evaluated. In the no action alternative, the contaminated soil and groundwater would be left "as is" but would be monitored on a continuing basis.

2.4.2 Institutional Action

Institutional action includes various access controls and deed restrictions. Although this alternative provides no reduction of volume, mobility, or toxicity of the contaminants, it can reduce or eliminate direct exposure pathways and the resultant risk to the public.

2.4.3 Removal/Disposal

The removal or collection/disposal option consists of removing the contaminated medium by various hydraulic, pneumatic, or mechanical means and directly disposing of this medium in an onsite or offsite facility.

2.4.4 Containment

Another method of reducing the risk to the public is through containment, thus reducing the mobility of the contaminants and reducing the likelihood of exposure by direct contact. To reduce mobility, the contaminated media must be isolated from the primary transport mechanisms such as wind, surface water, groundwater, biological means, and mechanical means. The isolation of the contaminated media may be accomplished by the installation of surface and subsurface barriers to either block or redirect any transport media away from the contaminants.

2.4.5 *In-Situ* Treatment

In-situ treatment would use one of several chemical, biological, and/or physical treatment methods designed to reduce the toxicity, volume, or mobility of the contaminants present.

2.4.6 Containment/Treatment

The containment/treatment general response action would combine the same containment technologies and related process options as the containment and the in situ treatment general response actions.

2.4.7 Removal/Disposal

The last general response action adds a treatment technology to the removal/disposal general response action combination such that the contaminated medium is treated prior to disposal.

2.5 Identification and Screening of Technology Types and Process Options

2.5.1 Screening and Evaluation Process

For each medium, a list of remedial technologies and process options were identified. These technologies were compiled from various USEPA documents as well as other applicable references.

An initial screening was performed to eliminate process options and possibly entire technology types based on technical feasibility. This required reviewing the process options relative to their applicability to the site-specific conditions to reduce the original number of possible options to a smaller, more manageable number. Following the initial screening, the remaining technology types and process options were evaluated based on technical implementability, effectiveness, and cost.

The results of this two-step screening/evaluation process are intended to provide a basis for selection of representative technologies that may be included during the development and screening of remedial alternatives phase of the FS (Section 3.0).

2.5.2 Technology Descriptions

A glossary of technologies/process options is presented in Appendix A.

2.5.3 Surface and Near-Surface Soil Medium

2.5.3.1 Identification and Screening of Technologies

The general response actions (Section 2.4) applicable for the surface and near-surface soil medium are no action, institutional action, containment, removal, treatment, disposal, and selected combinations of these. Based on these general response actions, several technologies and process options were identified for the surface and near-surface soil medium. The technologies and process options for surface and near-surface soil, which were deemed technically feasible during the initial screening process, are summarized in Table 2.4.

2.5.3.2 Evaluation and Selection of Representative Technologies

Table 2.4 lists the technologies and process options retained from the initial screening. These technologies and process options were carried through for further evaluation based on technical implementability, effectiveness, and cost. The bolded text on Table 2.4 indicates options retained during the evaluation process. Notes explaining the rationale behind eliminating and/or retaining the technologies are presented in Table 2.4.

The following technologies were retained either as stand alone technologies or to be used in combination with other technologies during the assembly of remedial alternatives: no action, monitored natural attenuation, grading, revegetation, clay/synthetic cap, soil cover, excavation, soil washing, onsite backfill, and offsite disposal to a RCRA landfill.

2.5.4 Upper Vadose Zone Soil Medium

2.5.4.1 Identification and Screening of Technologies

The general response actions (Section 2.4) applicable for the upper vadose zone soil medium are no action, institutional action, containment, removal, treatment, disposal, and selected combinations of these. Based on these general response actions, several technologies and process options were identified for the upper vadose zone soil medium. The technologies and process options for upper vadose zone soil, which were deemed technically feasible during the initial screening process, are summarized in Table 2.4.

2.5.4.2 Evaluation and Selection of Representative Technologies

Table 2.5 lists the technologies/process options retained from the initial screening. These technologies and process options were carried through for further evaluation based on technical implementability, effectiveness, and cost. The bolded text on Table 2.5 indicates options retained during the evaluation process. Notes explaining the rationale behind eliminating and/or retaining the technologies are presented in Table 2.5.

The following technologies were retained either as stand alone technologies or to be used in combination with other technologies during the assembly of remedial alternatives: no action, monitored natural attenuation, vapor extraction, oxidation/reduction, reductive dechlorination, anaerobic treatment, electrical resistance heating, excavation, soil washing, and onsite backfill.

2.5.5 Lower Vadose Zone Soil Medium

2.5.5.1 Identification and Screening of Technologies

The general response actions (Section 2.4) applicable for the lower vadose zone soil medium are no action, institutional action, containment, treatment, and selected combinations of these. Based on these general response actions, several technologies and process options were identified for the lower vadose zone soil medium. The technologies and process options for lower vadose zone soil, which were deemed technically feasible during the initial screening process, are summarized in Table 2.4.

2.5.5.2 Evaluation and Selection of Representative Technologies

Table 2.6 lists the technologies/process options retained from the initial screening. These technologies and process options were carried through for further evaluation based on technical implementability, effectiveness, and cost. The bolded text on Table 2.6 indicates options retained during the evaluation process. Notes explaining the rationale behind eliminating and/or retaining the technologies are presented in Table 2.6.

The following technologies were retained either as stand alone technologies or to be used in combination with other technologies during the assembly of remedial alternatives: no action, monitored natural attenuation, vapor extraction, oxidation/reduction, reductive dechlorination, anaerobic treatment, and electrical resistance heating.

2.5.6 Perched Groundwater Medium

2.5.6.1 Identification and Screening of Technologies

The general response actions (Section 2.4) applicable for the perched groundwater medium are no action, institutional action, containment, removal, treatment, disposal, and selected combinations of these. Based on these general response actions, several technologies and process options were identified for the perched groundwater medium. The technologies and process options for perched groundwater, which were deemed technically feasible during the initial screening process, are summarized in Table 2.4.

2.5.6.2 Evaluation and Selection of Representative Technologies

Table 2.7 lists the technologies/process options retained from the initial screening. These technologies and process options were carried through for further evaluation based on technical implementability, effectiveness, and cost. The bolded text on Table 2.7 indicates options retained during the evaluation process. Notes explaining the rationale behind eliminating and/or retaining the technologies are also presented in Table 2.7.

The following technologies were retained either as stand alone technologies or to be used in combination with other technologies during the assembly of remedial alternatives: no action, monitored natural attenuation, permeable reactive barrier, pumping wells, dual-phase extraction, vapor extraction, oxidation/reduction, electrical resistance heating, and aerobic/anaerobic bioremediation.

2.5.7 Exposition Zone Groundwater Medium

2.5.7.1 Identification and Screening of Technologies

The general response actions (Section 2.4) applicable for the Exposition zone groundwater medium are no action, institutional action, containment, removal, treatment, disposal, and selected combinations of these. Based on these general response actions, several technologies and process options were identified for the Exposition zone groundwater medium. The technologies and process options for Exposition zone groundwater, which were deemed technically feasible during the initial screening process, are summarized in Table 2.4.

2.5.7.2 Evaluation and Selection of Representative Technologies

Table 2.8 lists the technologies/process options retained from the initial screening. These technologies and process options were carried through for further evaluation based on technical implementability, effectiveness, and cost. The bolded text on Table 2.8 indicates options retained during the evaluation process. Notes explaining the rationale behind eliminating and/or retaining the technologies are also presented in Table 2.8.

The following technologies were retained either as stand alone technologies or to be used in combination with other technologies during the assembly of remedial alternatives: no action, monitored natural attenuation, permeable reactive barrier, pumping wells, dual-phase extraction, vapor extraction, oxidation/reduction, electrical resistance heating, and aerobic/anaerobic bioremediation.

2.6 Identification and Screening of *Ex-Situ* Post-Collection Technology Types and Process Options

Due to known community concern about *ex-situ* treatment of contaminated media, *ex-situ* treatment options were screened and evaluated in more detail than the process options/technologies designed for the five media zones. The *ex-situ* technology screening and evaluation process involved a more rigorous approach in order to select treatment technologies capable of destroying and/or reducing site-specific contaminants to concentrations below discharge requirements.

It should be noted that the disposal options for treated groundwater were integrated into this screening/evaluation process.

2.6.1 Screening and Evaluation Process

For each medium (water and vapor), a list of *ex-situ* treatment technologies was identified. These technologies were compiled from various USEPA documents as well as other applicable references. Only technologies that were potentially applicable and/or technically feasible were included. An initial screening was performed to eliminate process options and possibly entire technology types based on technical feasibility. This required reviewing the process options relative to their applicability to the site-specific conditions to reduce the original number of possible options to a smaller, more manageable number.

Following the initial screening, the remaining technology types and process options were evaluated based on technical implementability, effectiveness, and cost, such as was performed for the five media zones. Based on site contaminants and contaminant concentrations, the most effective technologies for *ex-situ* groundwater treatment and *ex-situ* vapor treatment were retained for a more detailed evaluation and for comparative analysis.

The results of the screening and detailed evaluation process are intended to provide representative technologies for *ex-situ* groundwater treatment and *ex-situ* vapor treatment for inclusion, if necessary, in the assembled remedial alternatives (Section 3.0).

2.6.2 *Ex-Situ* Groundwater Technology Screening

2.6.2.1 Identification and Screening of Technologies

Ex-situ groundwater treatment technologies were identified as part of the *ex-situ* treatment (post collection) general response action (Section 2.4). The technologies and process options for *ex-situ* groundwater treatment, which were deemed technically feasible during the initial screening process, are summarized in Table 2.9.

2.6.2.2 Evaluation of Technologies and Selection of Representative Technologies

Table 2.9 lists the technologies for *ex-situ* treatment of groundwater retained from the initial screening. These technologies and process options were carried through for further evaluation based on technical implementability, effectiveness, and cost. The following technologies were retained for *ex-situ* groundwater treatment during the initial evaluation process: liquid-phase granular activated carbon (GAC), air stripping, and ultraviolet oxidation (UV oxidation). The rationale behind retaining these technologies is presented in Table 2.9.

The *ex-situ* treatment technologies listed above were then evaluated in detail to select the preferred *ex-situ* alternative for treatment of extracted groundwater for use, if necessary, in the assembled remedial alternatives. Appendix B contains the detailed evaluation and comparative analysis of technologies for *ex-situ* groundwater treatment. Based on site contaminants, contaminant concentrations, and technology capabilities, the preferred *ex-situ* groundwater treatment technology is UV oxidation.

The treated groundwater may be disposed by one of the following retained disposal options: sewer system discharge, surface water discharge, or reinjection to subsurface.

2.6.3 *Ex-Situ* Vapor Technology Screening

2.6.3.1 Identification and Screening of Technologies

Ex-situ vapor treatment technologies were identified as part of the ex-situ (post collection) treatment general response action (Section 2.4). The technologies and process options for *ex-situ* groundwater treatment, which were deemed technically feasible during the initial screening process, are summarized in Table 2.10.

2.6.3.2 Evaluation of Technologies and Selection of Representative Technologies –

Table 2.10 lists the technologies for *ex-situ* treatment of vapor retained from the initial screening. These technologies and process options were carried through for further evaluation based on technical implementability, effectiveness, and cost. The following technologies were retained for *ex-situ* groundwater treatment during the initial evaluation process: vapor-phase GAC, catalytic oxidation, and flameless thermal oxidation (FTO). The rationale behind retaining these technologies is presented in Table 2.10.

The *ex-situ* treatment technologies listed above were then evaluated in detail to select the preferred *ex-situ* alternative for vapor treatment for use, if necessary, in the assembled remedial alternatives. Appendix B contains the detailed evaluation of technologies for *ex-situ* vapor treatment. Based on site contaminants, contaminant concentrations, and technology capabilities, the preferred *ex-situ* vapor treatment technologies are GAC and FTO.

3.0 DEVELOPMENT AND SCREENING OF REMEDIAL ALTERNATIVES

3.1 Introduction

The primary objective of this phase of the FS is to develop an appropriate range of waste management options, and through screening, select remedial alternatives that will be analyzed more fully in the detailed evaluation phase of the FS (Section 4.0).

Alternatives ensure the protection of human health and the environment and may involve, depending on site-specific circumstances, the complete elimination or destruction of hazardous substances at the site, the reduction of concentrations of hazardous substances to health-based levels (i.e., PSSRGs), and/or prevention of exposure to hazardous substances via engineering or institutional controls, or some combination of the above.

As defined in the NCP 300.430 (e)(2)(iii), TN&A developed a range of remedial alternatives that perform one or more of the following:

- Treatment that focuses on the reduction in the toxicity, mobility, or volume of hazardous substances and contaminants as a principal element. These alternatives actively remove or destroy contaminants of concern to the maximum extent feasible, eliminating or minimizing, to the degree possible, the need for long-term management;
- Treatment that focuses on the principal threats posed by the site but vary in the degree of treatment employed and the quantities and characteristics of the treatment residuals and untreated waste that must be managed;
- Little or no treatment, but provide protection of human health and the environment primarily by preventing or controlling exposure to hazardous substances, pollutants, or contaminants, through engineering controls, for example, containment, and, as necessary, engineering or institutional controls to protect human health and the environment and to assure continued effectiveness of the response action; and
- No further action as a baseline for comparison of alternatives.

During the development of alternatives, it was determined that the interrelationship between the five media zones (i.e., (1) surface and near-surface soils, (2) the upper vadose zone soils, (3) the perched groundwater, (4) the lower vadose zone soils, and (5) the Exposition groundwater zones) is not significant enough to warrant developing one set of remedial alternatives for the entire site. In fact, the features of the five media zones are very distinct. Therefore, TN&A developed an approach that identified combinations of media zones and treatment technologies for groundwater and soil that are compatible and provide a degree of economic or other benefit when used in conjunction with each other. This approach resulted in development of the organizing concept of three “remediation zones” consisting of:

- Surface and Near-Surface Soil Remediation Zone (0-3 ft bgs),
- Upper Vadose Soil and Perched Groundwater Remediation Zone (3-35 ft bgs), and
- Lower Vadose Soil and Exposition Groundwater Remediation Zone (35-100 ft bgs).

TN&A used these three remediation zones to organize the assembly of remedial alternatives for the FS and to support the basis for sound risk management decisions.

3.2 Basis for Development of Remedial Alternatives

The estimated quantity and composition of media to be remediated within each remediation zone as well as several key assumptions about subsurface conditions were vital to the development of remedial alternatives and are summarized in the following sections.

3.2.1 Key Assumptions

3.2.1.1 Stratigraphic Continuity of Lithosomes/Units

The lateral and vertical continuity of lithosomes, or sediment bodies of uniform deposition, vary within the study area and from unit to unit. For conceptual design purposes it is assumed that the hydrogeologic characteristics observed during drilling activities can be extrapolated to characterize subsurface conditions throughout the entire site vicinity. The assumptions are as follows:

- The perched saturated interval (25 to 30 ft bgs) ranges from a few inches to 4 ft thick and is absent in some areas where it is replaced by "high points" of the underlying "perching" clay. It is assumed that this interval is very low yielding (<0.5 gpm).
- The 'A' Zone ranges from a few inches (onsite) to 10 ft thick in some areas (south of Pemaco along District Blvd.) and is somewhat discontinuous. In the immediate site vicinity it is assumed that the 'A' zone is low yielding (<1 gpm).
- The Exposition 'B' Zone is continuous throughout the site vicinity, except in the area along District Blvd., south of 60th Street, where it "pinches out".
- The 'C' Zone appears to be continuous throughout the site vicinity within the 95 to 110 ft depth interval.

3.2.1.2 Hydraulic Parameters

An aquifer pumping test was performed between December 12th and December 24th, 2001 at the Pemaco site, primarily targeting the Exposition 'B' Zones ('B_1' and 'B_2'), which lie approximately 80 to 90 ft below the study area. The test was also performed to determine if a hydraulic connection between the 'A' (approximately 65 to 75 ft bgs) and 'B' groundwater zones exists.

Four types of aquifer tests, slug, step-drawdown, constant rate, and recovery, were performed to evaluate the hydrogeologic characteristics of the upper Exposition Aquifer system. These tests quantified parameters such as hydraulic conductivity, transmissivity, storage coefficient, well efficiency, and optimum pumping rates. These parameters were then used to calculate the effective radius of capture (ROC) for recovery wells that may be required for remediation purposes, establish the well design and configuration, and engineer the remediation equipment.

Results of data analysis/assumptions for remedial design are:

- Sustainable pumping rates from the 'B' Zone are approximately 1 gallon per minute (gpm) and approximately 0.5 gpm from the 'A' Zone.
- Calculated hydraulic conductivity (K) values for the 'A' Zone range from 8.3 E-04 to 2.3 E-03 feet per minute (ft/min).
- Calculated hydraulic conductivity (K) values for the 'B_1' Zone range from 1.3 E-03 to 7.1 E-02 ft/min.
- Calculated hydraulic conductivity (K) values for the 'B_2' Zone range from 1.1 E-03 to 2.7 E-02 ft/min.
- Pump test data indicated that the 'A' and 'B' Zones are hydraulically connected in a way consistent with a composite/leaky-confined aquifer.
- Average linear groundwater velocity (B_1 and B_2 Zones combined) is 0.47 feet/day (171 feet/year).

See Appendix C for a detailed description of the aquifer test and data analysis methods, hydraulic property calculations, best-fit curve graphs and raw data.

A pilot test for high-vacuum dual phase extraction (HVDPE) was performed in November and December 2002 for both the perched and Exposition 'A' and 'B' groundwater zones. The basic concept of the HVDPE system is to apply a high vacuum to the formation in order to induce fluid (vapor and water) flow. A high-vacuum pump supplies the vacuum to the well, either via direct connection to the casing ('A' and 'B' Zone tests) or to a drop tube (perched zone test), inducing groundwater flow. Individual tests on the 'A' and 'B' zones utilized a variable flow rate submersible pump as the primary method of groundwater extraction while the perched zone test utilized the drop-tube method as the depth to water in the groundwater zones stratigraphically associated with the Exposition Aquifer are generally too deep for liquid extraction using the drop-tube. It should be noted that the drop-tube method was successfully utilized during part of the 'A' Zone test, resulting in a higher sustained flow rate.

During the tests, samples and data were collected from all monitoring points and from the extraction wells prior to start up to establish baseline conditions for the following: vapor concentrations, well pressures, and water levels. During the startup of each system, vacuum levels and groundwater measurements were taken from all monitoring points, and extraction well samples were collected from the influent and effluent ports. The following data and samples were collected from the vacuum pump and influent and discharge ports: water flow, air/vapor flow, inlet vacuum level, inlet vapor concentration, discharge vapor concentrations from the carbon treatment system, inlet water to the separation tanks, discharge water in the storage tanks, total water flow, drop tube depth, and pump depth.

The performance of the system was evaluated based on the samples and data collected. Items evaluated or calculated per zone as follows:

Perched Zone (continual test time = 4.4 hrs day 1, 8.5 hrs day 2, total = 12.9 hours)
- HVDPE allowed for a sustained flow rate of 0.8 gpm;
- Vapor radius of influence (ROI) estimated at 54 feet;
- Groundwater extract ROI estimated at 72 feet;

- Wellhead vacuum at 14-inches of mercury (Hg) and flow measurement of 68 cfm;
- Tedlar flow tests – 10 ft away from SV-01 = 0.14 cfm with 1-ft screen;
- Tedlar flow tests – 50 ft from SV-01= 0.024 cfm with 15-ft screen; and
- Influent vapor concentrations = <10ppm, probably due to prior remediation of this zone.

'A' Zone (downhole-pump test time = 24 hours, drop-tube time = 3.6 hours)

- HVDPE allowed for a sustained flow rate of 0.6 to 0.8 gpm (pumping) and 1.1 gpm (drop-tube);
- Vapor ROI estimated at 37 feet;
- Groundwater extract ROI estimated at 175 feet;
- Wellhead vacuum at 20.58-inches of Hg with downhole pump and 15- to 17-inches of Hg with drop-tube;
- Tedlar flow tests during drop tube, 10 ft away from RW-01-70 = 0.10 cfm with 1.13 ft screen exposed to air;
- Influent vapor concentration = 700 to 1,000 ppm; and
- Drop tube method produced higher sustainable yield and presumably higher vapor flow because of the lower vacuum pressures. Drop tube produced more drawdown than pumping. Full potential of drop-tube not known due to short duration of test, water levels were still dropping after the 4 hours of testing.

'B' Zone (total test time = 21 hours, down-hole pump shut-off overnight for 11.5 hours of the testing, actual dual phase test = 9.5 hours)

- HVDPE allowed for a sustained flow rate between of 2 to 2.5 gpm, almost doubling non-vacuum sustained maximum yield of 1.2 gpm estimated from Aquifer Test data;
- Vapor ROI effectively 0 due to saturated screens of observation wells;
- Groundwater extract ROI estimated at 69 feet, actual ROI probably higher as the outlying well MW-14-90 was not used for this estimation;
- Wellhead vacuum at 25- to 25.5-inches of Hg; and
- Influent vapor concentration = <10 ppm, only part of formation exposed to vacuum was 'A' and 'B' fine-grained (which is probably semi-saturated thus further reducing permeability to air).

See Appendix D for a detailed description of the HVDPE pilot test and data analysis methods.

3.2.1.3 Vertical and Lateral Extent of Contamination

While screening and developing remedial alternatives for the Site, the following data gaps were acknowledged:

- No true upgradient monitoring well existed within the Exposition groundwater zones associated with the Pemaco Site due to the presence of the LA River channel (with respect to the direction of groundwater flow across the Site).

- No Exposition ‘C’ or ‘D’ Zone wells existed in the Pemaco source area to assess the vertical extent of groundwater contamination.

- Insufficient data existed to assess groundwater gradients in the Exposition ‘C’ and ‘D’ Zones, which are potentially contaminated.

Three double-nested wells were installed within the Exposition ‘A’ and ‘B’ groundwater zones between July 29th and July 31, 2003, to further delineate the northern fringe of the VOC plume in these zones. One set of wells was installed upgradient (as much as possible) along the northeast Pemaco property boundary; the other two sets of wells were installed cross gradient along the western Pemaco property boundary and on the W. W. Henry site. Analytical data collected from the newly installed ‘A’ and ‘B’ Zone wells substantiate previously delineated contaminant plumes within these zones.

Four additional ‘C’ Zone monitoring wells (MW-05-105, MW-23-110, MW-24-110 and MW-25-110) and three additional ‘D’ Zone monitoring wells (MW-23-145, MW-24-140 and MW-25-130) were installed between July 15th and August 12th, 2003 to address the ‘C’ and ‘D’ Zone data gaps. The wells were installed within the VOC “hot spot” south of the Pemaco property and along the periphery of the “hot spot” on 59th Place and Walker Street southwest of the site and on District Blvd south of the site. Data collected during well development activities reported nondetect to trace levels of VOCs with exception to TCE, which was detected in well MW-25-110 (‘C’ Zone) at a concentration of 6.0 µg/L and in well MW-24-140 (‘D’ Zone) at a concentration of 38 µg/L. All newly installed wells were again sampled during the October 2003 quarterly sampling event. Detectable concentrations of TCE were detected in wells MW-24-110, MW-25-110, MW-23-145, and MW-25-130 at concentrations ranging from 1.4 µg/L to 4.3 µg/L. Monitoring well MW-24-140 reported a TCE concentration of 120 µg/L. It is believed to be an anomaly that TCE is detected at higher concentrations in the ‘D’ Zone (MW-24-140) than in the ‘C’ Zone (MW-24-110). The Exposition ‘C’ and ‘D’ Zones will continue to be carefully monitored and will be addressed under separate documentation if remedial action is warranted.

3.2.1.4 “Source Area” Definition and Dimensions

Several original sources of contamination were identified at Pemaco during previous environmental investigations at the site including: a drum storage area in the southern portion of the site, 31 USTs, at least 6 ASTs, and a loading dock in the southwest corner of the property (Figure 3). For the purpose of this document, TN&A has defined “source areas” as heavily contaminated media (namely soils) that have free product or high concentrations of residual contamination, as the original sources are no longer present on the site.

Source areas within the Surface and Near-Surface Soil Remediation Zone are not believed to exist, as the contaminant concentrations are relatively homogenous. The majority of surficial soil contamination appears to lie along the periphery of the Pemaco site consistent with the fact that clean fill was placed over much of the site during previous removal actions. It is unlikely that the elevated metal and PAH concentrations detected in this zone are a result of previous activities on the Pemaco site (see Section 1.6.1).

For the two subsurface remediation zones, plumes delineated during RI activities were utilized for determining the source areas within each zone. The calculations for source area and volume were based on these plumes and are illustrated in Figure 14 (Upper Vadose Soil and Perched Groundwater Remediation Zone) and Figure 15 (Lower Vadose Soil and Exposition Groundwater Remediation Zone). The rationale for plume development and source area selection within each zone is outlined in more detail below.

- For the Upper Vadose Soil and Perched Groundwater Remediation Zone, three separate plumes (PCE, TCE, and VC) were originally delineated, as these constituents were the most prevalent and widespread within the perched groundwater. These plumes were overlapped to develop a conservative composite plume representative of maximum contamination within the perched groundwater zone. Several “hot spot” areas (groundwater concentrations exceeding 1,000 µg/L for either hydrocarbons or chlorinated VOCs) exist within the composite plume. However, as these “hot spots” have no continuity, the entire composite plume area (>ARARs/TBCs contour) was used to calculate an area and volume of material to be addressed within that zone.

- For the lower vadose zone soil and Exposition groundwater remediation zone, two TCE plumes were originally delineated, one for the Exposition ‘A’ Zone and one for the Exposition ‘B’ Zone. TCE was selected to represent maximum contamination within each zone, as it is the most prevalent and widespread compound in both zones. These two plumes were overlapped to develop a composite plume for the Exposition ‘A’ and ‘B’ Zones. Because the Exposition composite plume clearly illustrates a source area (> 10,000 µg/L plume contour of TCE), the area and volume of material to be addressed within this area was calculated specifically to facilitate source reduction technologies. An area and volume of material to be addressed within the entire composite TCE plume area (> 5.0 µg/L plume contour of TCE) was also calculated to facilitate containment technologies.

The soil and groundwater dimensions were derived within each subsurface remediation zone assuming that all soil and groundwater within the appropriate contour interval was contaminated to the same degree throughout the entire depth interval (e.g., 3-35 ft bgs, 35-100 ft bgs). The dimensions of contaminated media within each remediation zone are discussed in more detail in Section 3.2.2 below. The tables provided in Section 3.4 provide a tabulated summary of the dimensions and assumptions utilized for each remedial alternative.

3.2.2 Quantity and Composition of Media to be remediated

3.2.2.1 Surface and Near-Surface Soil Remediation Zone (0 – 3 feet bgs)

As discussed in Section 1.9.1, 2,220 cubic yards of metal- and SVOC-contaminated surface and near-surface soils exist within the Pemaco site boundary and the adjacent LAJR property north of 59th Place and south of Slauson Avenue (Figure 10). These volumes were used in the conceptual design for remedial alternatives addressing surface and near-surface soil.

3.2.2.2 Upper Vadose Soil and Perched Groundwater Remediation Zone (3 – 35 feet bgs)

An estimated 82,500 cubic yards of VOC-contaminated upper vadose zone soil exists within the Pemaco boundary as a result of a Pemaco release. This estimate is based on the assumption that contamination exists throughout the entire upper vadose zone thickness (3 ft to 35 ft bgs). If the entire perching clay is included in its entirety, approximately 95,400 cubic yards of VOC-contaminated upper vadose zone soil exists within the Pemaco boundary (between 3 ft and 40 ft bgs). The average concentration of VOCs in upper vadose zone soil samples is 6,600 µg/kg, based on discrete soil samples collected during RI activities. The average concentration of VOCs in lower vadose soil/soil vapor concentrations is considered to be much higher based on: 1) HVDPE treatability test results and 2) real-time and discrete sampling data collected in August 2003 with a cone penetration testing (CPT) rig equipped with a membrane interface probe (MIP).

Approximately 504,000 gallons of VOC-contaminated groundwater exist within the perched groundwater zone within the Pemaco site boundary. Approximately 1,390,000 gallons of VOC-contaminated groundwater is present within the perched groundwater zone within the Pemaco site boundary and adjacent properties as a result of a Pemaco-release. Volume was based on the ARAR exceedance contour of the composite perched zone (PCE, TCE, and vinyl chloride) plume (Figure 14). The average concentration of VOCs in the perched groundwater zone is 469 µg/kg.

These volume and concentration values were used in the design of assembled remedial alternatives addressing the Upper Vadose Soil and Perched Groundwater Remediation Zone.

3.2.2.3 Lower Vadose Soils and Exposition Zone Groundwater Remediation Zone (35 – 100 feet bgs)

Approximately 14,100 cubic yards of VOC-contaminated lower vadose zone soil is present within the Pemaco site boundary as a result of a Pemaco release. For the purpose of volume calculation, contamination was assumed to exist throughout the entire lower vadose zone thickness (35 to 65 ft bgs) within the Pemaco site boundary. The average concentration of VOCs in lower vadose zone soils is 9,400 µg/kg, based on discrete soil samples collected during RI activities. The average concentration of VOCs in lower vadose soil/soil vapor concentrations is considered to be much higher based on: 1) HVDPE treatability test results and 2) real-time and discrete sampling data collected in August 2003 with a CPT rig equipped with an MIP.

TCE was selected for volume calculations in the Exposition groundwater zones, as TCE is the most concentrated and widely dispersed VOC within the ‘A’ and ‘B’ zones. Approximately 15,600,000 gallons of TCE-contaminated groundwater exists within the ‘A’ and ‘B’ Zones in the vicinity of the Pemaco area. This estimate is based an overlay of the ‘A’ and ‘B’ Zone TCE plumes, a 552,000 sq ft area based on concentrations greater than 5.0 ppb (Figure 15). The average concentration of VOCs in the ‘A’ and ‘B’ groundwater zones within the 5.0 ppb plume contour is 4,600 µg/kg.

Based on the same composite plume, approximately 1,950,000 gallons of TCE-contaminated groundwater exists within the ‘A’ and ‘B’ groundwater zones at a concentration greater than 1,000 µg/L and approximately 302,000 gallons of TCE-contaminated groundwater exists at a concentration greater than 10,000 µg/L (based on >1,000 ppb and > 10,000 ppb TCE composite plume contours, respectively). The average concentration of VOCs within the 1,000 ppb-plume contour of these zones is 13,000 µg/kg; the average concentration of VOCs within the 10,000 ppb-plume contour of these zones is 16,700 µg/kg. These volume and concentration values were used in the conceptual design for remedial alternatives addressing lower vadose zone soil and Exposition Zone groundwater.

These volume and concentration values were used in the design of assembled remedial alternatives addressing Lower Vadose Soil and Exposition Zone Groundwater Remediation Zone.

3.3 Screening of Assembled Remedial Alternatives

3.3.1 Introduction

Based on RAOs, the quantity and composition of media to be remediated, key assumptions, and technical project meetings, the process options that passed the screening evaluation for surface/near-surface soil, upper vadose soil, perched groundwater, lower vadose soil, Exposition groundwater, *ex-situ* groundwater, and *ex-situ* vapor were assembled into remedial action alternatives. The retained process options are summarized in Table 3.0 by both media and remediation zone.

The retained process options/technologies were then assembled into a total of 26 remedial action alternatives (5 for the Surface and Near-Surface Soil Remediation Zone, 11 for the Upper Vadose Soil and Perched Groundwater Remediation Zone, and 10 for the Lower Vadose Soil and Exposition Groundwater Remediation Zone).

Remedial alternatives assembled for the two upper remediation zones (Surface and Near-Surface Soil Remediation Zone and the Upper Vadose Soil and Perched Groundwater Remediation Zone) typically utilize one to two remedial technologies to address the entire area of contamination, as contaminant concentrations are relatively homogenous within these zones.

Remedial alternatives assembled for the Lower Vadose Soil and Exposition Groundwater Remediation Zone typically include multiple remedial technologies, as this zone has clearly delineated areas with varying degrees of contamination (i.e., 10,000 µg/L-contour, 1,000 µg/L-contour, 100 µg/L-contour, and 10 µg/L-contour of the composite Exposition ‘A’ and ‘B’ Zone TCE plume). The contours of the composite Exposition ‘A’ and ‘B’ Zone TCE plume were used to define the application of suitable remedial technologies based on contaminant volume and concentration to assemble an effective remedial alternative for this zone.

Once an appropriate range of waste management options was developed for each remediation zone, the remedial alternatives were screened based on effectiveness, implementability, and cost. Remedial alternatives that were retained during this initial screening process will be analyzed more fully in the detailed evaluation phase of the FS (Section 4.0).

The screening of remedial alternatives is discussed in more detail by remediation zone in the following sections.

3.3.2 Surface and Near-Surface Soil Remediation Zone

The assembled remedial alternatives considered for this zone are summarized in Table 3.1. The bolded text on Table 3.1 indicates remedial alternatives retained during the screening process as well the rationale behind retaining these alternatives.

The following remedial alternatives were retained for the Surface and Near-Surface Soil Remediation Zone:

- No Action
- Soil Cover/Revegetation

- Excavation/Offsite Disposal

In general, remedial alternatives that were *not* retained had technical and/or administrative limitations (see Appendix E for detailed descriptions and evaluations of the discarded alternatives).

3.3.3 Upper Vadose Soil and Perched Groundwater Remediation Zone

The assembled remedial alternatives considered for this zone are summarized in Table 3.2. The bolded text on Table 3.2 indicates remedial alternatives retained during the screening process as well the rationale behind retaining these alternatives.

The following technologies were retained for the Upper Vadose Soil and Perched Groundwater Remediation Zone:

- No Action
- High-Vacuum Dual-Phase Extraction/Ultraviolet Oxidation/Flameless Thermal Oxidation/Granular Activated Carbon
- High-Vacuum Dual-Phase Extraction/Ultraviolet Oxidation/Granular Activated Carbon
- *In-situ* Chemical Oxidation
- Enhanced *In-situ* Bioremediation
- Monitored Natural Attenuation

In general, remedial alternatives that were discarded had technical and/or administrative limitations (see Appendix E for detailed descriptions and evaluations of the discarded alternatives).

3.3.4 Lower Vadose Soil and Exposition Groundwater Remediation Zone

The assembled remedial alternatives considered for this zone are summarized in Table 3.3. The bolded text on Table 3.3 indicates remedial alternatives retained during the screening process as well the rationale behind retaining these alternatives.

The following technologies were retained for the Lower Vadose Soil and Exposition Groundwater Remediation Zone:

- No Action
- *In-situ* Chemical Oxidation/*In-situ* Chemical Reduction/Groundwater Extraction/ Monitored Natural Attenuation/Ultraviolet Oxidation
- Enhanced *In-situ* Bioremediation/Groundwater Extraction/Monitored Natural Attenuation/Ultraviolet Oxidation
- Vacuum Extraction/Groundwater Extraction/Monitored Natural Attenuation/Ultraviolet Oxidation/ Flameless Thermal Oxidation/Granular Activated Carbon
- Vacuum Extraction/Groundwater Extraction/Monitored Natural Attenuation/Ultraviolet Oxidation/ Granular Activated Carbon
- Electrical Resistance Heating/Vapor Extraction/Groundwater Extraction/Monitored Natural Attenuation/Ultraviolet Oxidation/Flameless Thermal Oxidation/Granular Activated Carbon
- Electrical Resistance Heating/Vapor Extraction/Groundwater Extraction/Monitored Natural Attenuation/Ultraviolet Oxidation/Granular Activated Carbon

In general, remedial alternatives that were discarded had technical and/or administrative limitations (see Appendix E for detailed descriptions and evaluations of the discarded alternatives).

3.4 Remedial Alternative Descriptions

Table 3.4 provides a summary of remedial alternatives retained during the screening of remedial alternatives phase of the FS process (Section 3.3). Descriptions of the retained remedial alternatives for each remediation zone – surface and near-surface soils (0 to 3 ft bgs), upper vadose zone soil and perched groundwater zone (3 to 35 ft bgs), and lower vadose zone soil and Exposition groundwater zones (35 to 100 ft bgs) – are presented in Sections 3.4.1 through 3.4.3 below.

3.4.1 Alternatives for Surface and Near (N) Surface Soil (0 to 3 ft bgs) Remediation Zone

The Surface and Near-Surface Soil Remediation Zone poses risks of human exposure to current trespassers, future park users, future excavation workers, and future onsite residents by direct contact (ingestion and/or dermal contact) with soils containing COCs. Five remediation alternatives were identified to reduce these risks during the screening of process options and remedial alternatives for surface and near-surface soils. The assembled alternatives also address the migration of COCs in surface and near-surface soils to the perched groundwater, although the COCs in this zone are characteristically non-mobile and are not expected to migrate.

3.4.1.1 Alternative N1 – No Action

As required by the NCP, the “No action” alternative must be included as a remedial alternative to provide a baseline for evaluation of the remedial process options.

The No Action alternative does not involve any proactive treatment, removal, or monitoring of the contaminated media. In surface and near-surface soils soil, COCs consisting of metals and SVOCs exist at concentrations above TBCs (U.S. EPA Region IX PRGs). Under this alternative, pathways for human exposure via inhalation, ingestion, or dermal contact, and pathways for migration via wind and surface water runoff will persist.

3.4.1.2 Alternative N2 – Soil Cover/Revegetation

Alternative N2 – Soil Cover/Revegetation *Surface and Near-Surface Soil Remediation Zone*	
Alternative Description	
Soil cover involves emplacement of a layer of soil, typically one-ft or greater in thickness, and establishing vegetative growth to stabilize the soil in place. The soil cover does not treat or destroy the COCs but acts as containment and eliminates the pathways to human exposure. Long-term monitoring and maintenance of the soil cover and vegetative growth is essential to prevent erosion and exposure of the underlying contaminants. Implementation of a soil cover would be coupled with another process option that would contain or treat groundwater and vadose zone soil. Unlike an impermeable cap, a soil cover allows for percolation of precipitation and irrigation water into the subsurface. Percolation of water through surface soils poses a minor concern since the metal and SVOC COCs are not very mobile in the environment and tend to adhere tightly to their soil matrix. The completed soil cover could serve as a recreational area following revegetation.	
Site Characteristics	
Area To Be Graded and Covered:	
Area of Pemaco Site:	65,000 ft^2
Area of adjacent railway:	22,500 ft^2
Preparation of Subgrade:	
Concrete area to be removed or broken in place:	13,000 ft^2
Thickness:	6 in
Volume:	240 yd^3
Vegetated area to be disposed/composted:	51,952 ft^2
Thickness:	3 in (assumed)
Volume to be hauled/disposed:	480 yd^3
Fence length adjoining railway to be removed:	540 ft
Volume (rough estimate) to be hauled/disposed:	60 yd^3
Cover Soil:	
Volume, 1-foot (1.4 x actual volume to account for compaction):	4,550 yd^3
Topsoil volume, 4 in:	1,080 yd^3
Surface Restoration:	
Vegetative cover to be established as needed:	87,500 ft^2
Conceptual Design Components and Assumptions	
Component	**Assumptions**
Preparation of Subgrade: Includes clearing existing vegetation and fixtures such as concrete pads, walls, fencing, rail lines, etc. with the intent of creating a suitable surface for the application of cover soils. Semi-impermeable surfaces, such as concrete pads, promote uneven drainage patterns, ponding, or subsurface erosion, which can lead to slips and cracks in the cover. Therefore, the concrete pads should be removed or broken-up in place and compacted into the subgrade so that drainage is promoted.	• Concrete will be broken-up and left in place; i.e. no hauling. • Monitoring well relocation will take place under Maywood Riverfront Park Project • Removal of fencing except north, east, and south site boundary.
Disposal: Vegetation can be composted or disposed of at a RCRA Subtitle D landfill.	• All vegetation will be hauled to a composting facility. • All concrete will be broken-up and remain in place. • Fencing will be hauled to a recycler.
Earthwork: To strip vegetation, prepare ground surface to receive cover soil, achieve desired control of run-on/runoff, and to accommodate future use.	• City of Maywood provides grading plan. • Cuts made into 'clean' soil will be used as fill at other areas within the Site. • Adequate compaction is assumed following rough grading.

Alternative N2 – Soil Cover/Revegetation (cont'd) *Surface and Near-Surface Soil Remediation Zone*	
Conceptual Design Components and Assumptions	
Component	**Assumptions**
Cover Soil Application: Lifts should not be greater than 8 inches followed by compaction to 90% of maximum density. Must be capable of supporting vegetative growth such as a sandy loam.	• 1-ft of cover soil. • Finish grading - to smooth out surface and apply topsoil. • 4 in of topsoil.
Surface Restoration: Broadcast seed or sod, install rooted plants, or prepare for landscaping in accordance with City of Maywood Riverfront Park plans.	• The City of Maywood will provide the Park landscaping plans, which will determine how the surface is landscaped and vegetation established. • Land surveys to define new cover elevations and extent.
Annual Operation and Maintenance:	• Budget for regular maintenance, irrigation, surveying and repair of cover surface.
Additional Remedial Action Required:	• Soil cover would be implemented with other remedial process option that addresses vadose zone and groundwater contamination.
Duration Range for Soil Cover Construction:	Approximately 1 to 2 months
Conceptual Design Considerations	
Residential neighborhoods are located to the south of and adjacent to the Pemaco Site. The City of Maywood intends to accept available grants to convert the Pemaco Site and adjoining properties, including: the railway right-of-way, Precision Arrow, W.W. Henry, Catellus, and Lubrication and Oil Services, to a recreational area named the Maywood Riverfront Park.	

3.4.1.3 Alternative N3 – Excavation and Offsite Disposal

Alternative N3 – Excavation and Offsite Disposal *Surface and Near-Surface Soil Remediation Zone*	
Alternative Description	
Soil excavation and offsite disposal involves removal of the impacted surface and near-surface soils and disposal of the soil offsite at an approved landfill. By removing the impacted soil, pathways for human exposure and potential for migration of surface contaminants are eliminated; and a greater buffer zone is created between surface activities and vadose zone soils. Following soil removal, the site would be regraded and revegetated similar to the soil cover option above. Since the components of a soil cover and design assumptions are discussed above, this section will focus on the excavation, disposal characterization sampling, and disposal phases.	
Site Characteristics	
Contaminated Soil Areas:	25 by 25 ft grids identified in RI
Depths to be Excavated: Refer to the Excavation Volume Calculation Worksheet under the Supporting Documentation Tab.	• 1-ft depth excavated for 0.5 ft sample exceedance • 3-ft depth excavated for 2.5 ft sample exceedance
Volume of soil to be excavated:	2,900 yd^3
Volume of soil to be hauled for disposal (after expansion x 1.3):	3,770 yd^3 (6,630 tons)
Volume of concrete to be excavated and disposed:	250 yd^3
Volume of backfill required:	3,770 yd^3
Conceptual Design Components and Assumptions	
Component	**Assumptions**
Excavation: Conventional backhoe loader or excavator would be used.	• Suggested cleanup criteria is Residential PRGs for SVOCs and Metals (except Iron, which gets cleaned up to background levels) • Assume dust suppression (sprinkler truck) will be required.
Stockpiling: Excavated soil would be covered and held in roll-offs or on plastic sheeting until analytical results are evaluated.	• Process train based on 400 yd^3 excavated per day • 20 yd^3 per roll off or pile based on weight limit for hauling • 3 day staging requirement for analytical evaluation = 20 piles/day x 3 days = 60 pile requirement
Sampling Regimen: One composite sample per 20 c.y. analyzed for VOCs, SVOCs, and metals.	• Assume rapid (24 hrs) analytical turnaround time (TAT) • Assume all analytical results come back "dirty" and soil must be disposed of offsite. If clean soil is identified, it could be used for backfill.
Disposal: Roll off bins would be manifested and hauled to closest approved treatment/disposal facility. The removal and transportation of contaminated materials involves the increased potential for human exposure and efforts to comply with RCRA regulations.	• Assume 20 trucks per day depart the site for approximately 9 days.
Backfill: Apply typical sandy backfill in 8-inch lifts, compact, continue to grade.	• Backfill required only to fill excavations. No additional cover soil intended.

Alternative N3 – Excavation and Offsite Disposal (cont'd) *Surface and Near-Surface Soil Remediation Zone*	
Conceptual Design Components and Assumptions	
Component	**Assumptions**
Surface Restoration: Broadcast seed or sod, install rooted plants, or prepare for landscaping in accordance with City of Maywood Riverfront Park plans.	• The City of Maywood will provide the Park landscaping plans, which will determine how the surface is landscaped and vegetation established.
Additional Remedial Action Required:	• Excavation and offsite disposal implemented with other remedial process option that addresses vadose zone and groundwater contamination.
Duration Range for Excavation and Offsite Disposal:	Approximately 1.5 months
Conceptual Design Considerations	
Residential neighborhoods are located to the south of and adjacent to the Pemaco Site. The City of Maywood intends to convert the Pemaco Site and adjoining properties including: the railway right-of-way, Precision Arrow, W.W. Henry, Catellus, and Lubrication and Oil Services, to a recreational area named the Maywood Riverfront Park.	

3.4.2 Alternatives for Upper Vadose Soil (S) and Perched (P) Groundwater (3 to 35 feet bgs) Remediation Zone

The Upper Vadose Soil and Perched Groundwater Remediation Zone poses risks of human exposure to future excavation workers, future onsite residents, and future offsite residents by direct contact (inhalation, ingestion, and/or dermal contact) with soils, groundwater, and/or soil vapors containing COCs. Nine remediation alternatives were identified to reduce these risks during the screening of process options and remedial alternatives for upper vadose soils and the perched groundwater zone. The assembled alternatives also address vertical migration of COCs to deeper groundwater zones, further lateral migration of COCs onto adjacent properties, and groundwater restoration per the State of California antidegradation policy (SWRCB Resolution No. 68-16).

3.4.2.1 Alternative SP1 – No Action

As required by the NCP, the "No Action" alternative must be included as a remedial alternative to provide a baseline for evaluation of the remedial process options.

The No Action alternative does not involve any proactive treatment, removal, or monitoring of the contaminated media. In the Upper Vadose Soil and Perched Groundwater Remediation Zone (3 to 35 ft bgs), VOCs exist at concentrations above the U.S. EPA Region IX PRGs and USEPA and CalEPA MCLs, respectively. During site redevelopment, excavation workers may be exposed to COCs via ingestion, dermal contact, and inhalation of upper vadose soils. Residual VOC contamination in upper vadose soils can migrate to the surface in vapor form and create a pathway for human exposure to COCs via inhalation. On the other hand, residual VOC contamination may migrate downward and act as a continued source of deeper groundwater zones. No Action for the Upper Vadose Soil and Perched Groundwater Remediation Zone would not be protective of human health as future excavation workers and residents may be exposed to COCs. In addition, groundwater quality would no be restored to ARARs and/or local background.

3.4.2.2 Alternative SP2a – High-Vacuum Dual-Phase Extraction/Ultraviolet Oxidation/ Flameless Thermal Oxidation/Granular Activated Carbon

Alternative SP2a – High-Vacuum Dual-Phase Extraction/Ultraviolet Oxidation/ Flameless Thermal Oxidation/Granular Activated Carbon *Upper Vadose Soil and Perched Groundwater Remediation Zone*
Alternative Description
High-vacuum dual-phase extraction (HVDPE) utilizes high vacuum to extract groundwater and soil vapor from the contaminated zones. Typical groundwater extraction wells screened through the contaminated soil and perched groundwater would be installed to remove contaminants in both the gas and liquid phase. Drawdown caused by groundwater extraction exposes additional well screen area from which soil vapor is extracted; thereby removing VOCs trapped in the soil pores. The contaminated groundwater and soil vapor are transported to separate above ground treatment systems where the contaminants are removed prior to discharge. This alternative utilizes ultraviolet oxidation (UV Ox) for groundwater treatment and flameless thermal oxidation (FTO) and granular activated carbon (GAC) for vapor treatment. Both UV Ox and FTO would completely destroy all COCs on-site with no residual wastes to manage. Assuming cleanup criteria are met, the treated groundwater could be disposed by reinjection back into the aquifer, discharge to the sanitary sewer, or discharge to the LA River (depending on permit approval). Likewise, the treated soil vapor would discharge to the air above the site.

Alternative SP2a – High-Vacuum Dual-Phase Extraction/Ultraviolet Oxidation/ Flameless Thermal Oxidation/Granular Activated Carbon (cont'd) *Upper Vadose Soil and Perched Groundwater Remediation Zone*	
Alternative Description	
This alternative assumes that that initial high mass loading of VOCs extracted during the first year of operation would be more effectively and efficiently treated using FTO. Due to the 99.9% destruction effectiveness rate of FTO, the production of combustion by-products (e.g., dioxin) above background concentrations is unlikely. After the first year, it is estimated that the mass loading will be significantly reduced and switching to a GAC vapor treatment system would be more cost effective. GAC absorbs COCs from the extracted vapor for later disposal at an off-site approved facility. GAC is not an effective method of treatment for low molecular weight VOCs, such as vinyl chloride, or COCs with low adsorptive capacity, such as 1,4-dioxane. However, it is estimated that a significant proportion of these two contaminants would be eliminated in the first year to allow for treatment via GAC. Further evaluation of the proportion of these COCs in the vapor stream would be necessary prior to implementing GAC vapor treatment. Assuming cleanup criteria are met, the treated soil vapor would discharge to the air above the site. HVDPE allows for good control over contaminant mobility and a reduction in contaminant volume (onsite) for both soil and groundwater. HVDPE would effectively eliminate the potential for migration of COCs in this remediation zone and the pathways to human exposure to COCs in both upper vadose soils and the perched groundwater.	
Site Characteristics	
Area of Source control:	
Soil Area (based on exceedances of DAF 20 SSLs):	69,600 ft^2
Approximate Thickness:	32 ft (3 to 35 ft bgs) 37 ft (3 to 40 ft bgs including perching clay)
Volume:	82,500 yd^3 to 95,400 yd^3
Perched Groundwater Area:	168,000 ft^2
Approximate Thickness:	2 to 3 ft (top of perching clay 25 to 35 ft bgs)
Analytical Data:	
Maximum concentration of Primary COCs in Upper Vadose Zone soils:	• Acetone (16,000 µg/kg) • Benzene (4,100 µg/kg) • DCE (400 µg/kg) • Cis-1,2-DCE (3,300 µg/kg) • Ethylbenzene (61,000 µg/kg) • Methylene chloride (530 µg/kg) • PCE (2,000 µg/kg) • Toluene (98,000 µg/kg) • TCE (3,300 µg/kg) • Vinyl chloride (280 µg/kg) • PAHs (630 to 40,000 µg/kg)
Maximum concentration of Primary COCs in Perched Zone groundwater:	• Benzene (1,600 µg/L) • PCE (1,100 µg/L) • TCE (680 µg/L), • cis-1,2-DCE (780 µg/L) • Vinyl chloride (240 µg/L) • 1,4-dioxane (920 µg/L)
Hydrogeologic Data:	
Depth to Perched Zone groundwater:	20 to 30 feet bgs
Direction/gradient of groundwater flow in Perched Zone:	Inconsistent due to perching clay
HVDPE Pilot Test Data:	• Vacuum ROI of 54 ft at 68 scfm and 14 in of Hg • GW extraction = 0.8 gpm
Potential Receptors: Residential neighborhoods are adjacent to the south of the site.	

Alternative SP2a – High-Vacuum Dual-Phase Extraction/Ultraviolet Oxidation/ Flameless Thermal Oxidation/Granular Activated Carbon (cont'd) *Upper Vadose Soil and Perched Groundwater Remediation Zone*	
Conceptual Design Components and Assumptions	
Component	**Assumptions**
HVDPE Well Networks: Thirty-two extraction wells will be installed to 35 ft bgs to provide coverage over the contaminated soil and perched groundwater area. Soil treatment area and treatment criteria will be based on U.S. EPA Region IX Soil SSLs DAF 20. Perched groundwater treatment area and criteria based on MCLs.	• Design vacuum ROI of 50 ft • Design GW extraction rate of 0.8 gpm per well. • Drop-vacuum-tube method to be implemented. • All wells shall be 4-inch diameter, Schedule 80 PVC. • Screened from 5 to 35 ft bgs.
Groundwater Treatment System: A fenced and covered treatment compound would be mounted on a 20 ft by 30 ft concrete pad with containment foundation (to be shared with vapor treatment). Electrical service and remote monitoring communication system would be tied into local services with possible back-up power generation. The treatment process would be UV oxidation since it is the most effective commercially available treatment technology used to treat 1,4-dioxane to levels suitable for discharge. Concentrations of 1,4-dioxane cannot be effectively removed for discharge using air stripping or GAC. UV-OX is a destruction process that oxidizes organic contaminants by adding oxidizing agents such as ozone (O_3) or hydrogen peroxide (H_2O_2) to the contaminated groundwater. The contaminated solution is passed through a chamber where it is exposed to intense UV radiation and oxidized into harmless byproducts.	• Design flow and influent conc. are 25 gpm and 500 ppb total VOC. • Treatment criterion is to be based on PSSRGs (Table 2.1). • Treatment system influent and effluent to be sampled daily during 7-day startup; quarterly after documented stabilization; semiannually after established trend or continued stabilization. Effluent sampling frequency would be determined by discharge permit. • Long-term O&M plan to be implemented for treatment system. • Influent trench and pipe = 1,200 ft • Effluent trench and pipe = 500 ft
Soil Vapor Treatment System: The selected soil vapor treatment process, FTO for the first year followed by GAC for the remaining years, would be housed in the treatment compound alongside the groundwater treatment system. Treatment criteria will be determined in accordance with the South Coast Air Quality Management District (SCAQMD) discharge permit. Target destruction efficiency would average 99% with concentrations of combustion by-products (e.g., dioxin) below background concentrations during FTO operation and low (approved) concentrations of vinyl chloride and 1,4 dioxane emissions during GAC operation.	• Total design system flow of 1,000 scfm based on 50% of wells on-line per extraction event. • Estimated initial influent vapor concentration of approximately 5.0 ppmv • Treatment system influent and effluent to be sampled daily during 7-day startup; weekly after documented stabilization or trend; quarterly or in accordance with discharge permit thereafter. • Additional monitoring via PID will be performed to supplement sampling data and to schedule timing for switching on-line wells. • Assumptions are based on HVDPE pilot test. (Refer to Appendix D for the results.)

Alternative SP2a – High-Vacuum Dual-Phase Extraction/Ultraviolet Oxidation/ Flameless Thermal Oxidation/Granular Activated Carbon (cont'd) *Upper Vadose Soil and Perched Groundwater Remediation Zone*	
Conceptual Design Components and Assumptions	
Component	**Assumptions**
Monitoring/Reporting Frequency: Reporting will be performed to maintain discharge permits, document contaminant removal rates, flows, cleanup forecasts, and groundwater gradient maps, in appropriate frequency to data collection.	• Semiannual groundwater sampling events are recommended. • Initial monthly monitoring of the GAC effluent will be performed to demonstrate acceptable concentrations of vinyl chloride and 1,4-dioxane. • Annual monitoring may be recommended after demonstration of reduction in plume volume and mobility. • QA/QC Program Plan will be instituted for all sampling and treatment. • Long term O&M plan required.
Estimated Project Duration: 5 years + minimum of 5 years monitoring.	Approximately 10 years.
Conceptual Design Considerations	
• Enhancements: Hydraulic or pneumatic fracturing could be used as an enhancement for removal of contaminant from source area. Targeted "fracing" zone would be the perching clay 28 to 35 ft bgs.	

3.4.2.3 Alternative SP2b – High-Vacuum Dual-Phase Extraction/Ultraviolet Oxidation/ Granular Activated Carbon

Alternative SP2b –High-Vacuum Dual-Phase Extraction/ Ultraviolet Oxidation/Granular Activated Carbon *Upper Vadose Soil and Perched Groundwater Remediation Zone*	
Alternative Description	
The treatment process is the same as described in Alternative SP2a with the exception of vapor treatment, which would employ only granular activated carbon (GAC). GAC absorbs COCs from the extracted vapor for later disposal at an off-site approved facility. GAC is not an effective method of treatment for low molecular weight VOCs, such as vinyl chloride, or COCs with low adsorptive capacity, such as 1,4-dioxane. Further evaluation of the proportion of low molecular weight VOCs in the vapor stream would be necessary prior to implementing GAC vapor treatment. Assuming cleanup criteria are met, the treated soil vapor would discharge to the air above the site.	
Site Characteristics	
The Site Characteristics are the same as Alternative SP2a.	
Conceptual Design Components and Assumptions	
Component	**Assumptions**
HVDPE Well Networks: See Alternative SP2a for the HVDPE Well Network.	Same as Alternative SP2a.
Groundwater Treatment System: See Alternative SP2a for the Groundwater Treatment System.	Same as Alternative SP2a.
Soil Vapor Treatment System: The selected soil vapor treatment process, GAC, would be housed in the treatment compound alongside the groundwater treatment system. Treatment criteria will be determined in accordance with the South Coast Air Quality Management District (SCAQMD) discharge permit. Target destruction efficiency would average 99% with low (approved) concentrations of vinyl chloride and 1,4 dioxane emissions during GAC operation.	Same as Alternative SP2a without FTO.
Monitoring/Reporting Frequency: Reporting would be the same as Alternative SP2a without the FTO system.	• Same as Alternative SP2a with the addition of: • Additional reporting of effluent monitoring data for vinyl chloride and 1,4-dioxane would be performed in accordance with the SCAQMD permit. .
Estimated Project Duration: Same as Alternative SP2a	• Approximately 10 years.
Conceptual Design Considerations	
Same as Alternative SP2a	

3.4.2.4 Alternative SP3 – *In-situ* Chemical Oxidation

<table>
<tr><th colspan="2">Alternative SP3 – In-situ Chemical Oxidation
Upper Vadose Soil and Perched Groundwater Remediation Zone</th></tr>
<tr><th colspan="2">Alternative Description</th></tr>
<tr><td colspan="2">In-situ Chemical Oxidation (ISCO) involves injecting the selected oxidizing agent into the subsurface and collecting and analyzing groundwater samples to monitor the degradation process. The contaminant concentrations (i.e., chlorinated ethenes), general chemistry parameters pertinent to the process (i.e., total organic carbon, peroxide, chloride, sulfate, manganese, and ferrous iron) and environmental indicators (i.e., pH, specific conductivity, oxidation-reduction potential, and turbidity) are documented prior to and following the injection events. Long-term monitoring includes additional parameters such as natural attenuation indicators (i.e., dissolved gases and selected anions). ISCO is not recommended for in-situ treatment of soil since the mechanics of substrate delivery are unproven and groundwater is required to assist with dispersion. For this reason, ISCO would only provide a partial treatment solution to the Upper Vadose Soil and Perched Groundwater Remediation Zone. Pathways to human exposure in upper vadose soils and the potential for migration of COCs would not be addressed.</td></tr>
<tr><th colspan="2">Site Characteristics</th></tr>
<tr><td>Area of Source control:</td><td></td></tr>
<tr><td>Soil Area (based on exceedances of the SSLs and DAF 20):</td><td>69,600 ft^2</td></tr>
<tr><td>Approximate Thickness:</td><td>32 ft (3 to 35 ft bgs)
37 ft (3 to 40 ft bgs including perching clay)</td></tr>
<tr><td>Volume:</td><td>82,500 yd^3 to 95,400 yd^3</td></tr>
<tr><td>Perched Groundwater Area:</td><td>168,000 ft^2</td></tr>
<tr><td>Approximate Thickness:</td><td>2 to 3 ft (top of perching clay 25 to 35 ft bgs)</td></tr>
<tr><td>Analytical Data:</td><td></td></tr>
<tr><td>Maximum concentration of COCs in Upper Vadose Zone soils:</td><td>• Acetone (16,000 µg/kg)
• Benzene (4,100 µg/kg)
• DCE (400 µg/kg)
• Cis-1,2-DCE (3,300 µg/kg)
• Ethylbenzene (61,000 µg/kg)
• Methylene chloride (530 µg/kg)
• PCE (2,000 µg/kg)
• Toluene (98,000 µg/kg)
• TCE (3,300 µg/kg)
• Vinyl chloride (280 µg/kg)
• PAHs (630 to 40,000 µg/kg)</td></tr>
<tr><td>Maximum concentration of COCs in Perched Zone groundwater:
TOC (5 to 30 mg/L) and pH (6.5 to 7.5) assumed from A Zone</td><td>• Benzene (1,600 µg/L)
• PCE (1,100 µg/L)
• TCE (680 µg/L),
• cis-1,2-DCE (780 µg/L)
• Vinyl chloride (240 µg/L)
• 1,4-dioxane (920 µg/L)</td></tr>
<tr><td>Hydrogeologic Data:</td><td></td></tr>
<tr><td>Depth to Perched Zone groundwater:</td><td>20 to 30 feet bgs.</td></tr>
<tr><td>Direction and gradient of groundwater flow in Perched Zone:</td><td>Inconsistent due to perching clay</td></tr>
<tr><td colspan="2">Miscellaneous: Residential neighborhoods are situated to the south of the site.</td></tr>
<tr><td>Bench Test: Collection of one sample per zone (total of 2 samples) to determine the actual volume of the oxidizing agent required per injection location for contaminant oxidation and complete degradation.</td><td>• Fenton's reagent or permanganate solution to be applied due to high contamination levels and complexity of site hydrogeology.
• Bench test will determine volume of reagent needed.</td></tr>
</table>

Alternative SP3 – *In-situ* Chemical Oxidation (cont'd) *Upper Vadose Soil and Perched Groundwater Remediation Zone*	
Conceptual Design Components and Assumptions	
Component	**Assumptions**
Bench Test: Collection of one sample per zone (total of 2 samples) to determine the actual volume of the oxidizing agent required per injection location for contaminant oxidation and complete degradation.	• Fenton's reagent or permanganate solution to be applied due to high contamination levels and complexity of site hydrogeology. • Bench test will determine volume of reagent needed.
Pilot Test: An ISCO pilot test would confirm project feasibility and design parameters prior to full-scale implementation. Baseline sampling (one-time event) prior to injection activity and one sampling event following each injection activity (a total of three sampling events) is expected over the 3-month pilot study period. Parameters to be monitored include: COCs (chlorinated ethenes), field parameters (pH, specific conductivity, ORP, and turbidity), and general chemistry parameters (total organic carbon, peroxide, chloride, sulfate, manganese, and ferrous iron).	• Treatment area: approx. 3,000 ft^2, thickness would be the entire perched zone. • Assume 15-foot ROI per injection point, and 3 injection locations. • Assume the oxidant and dose rate will be determined by the bench test. Since Fenton's reagent is the most aggressive, assume for the purposes of the conceptual design that a Fenton's reagent dose rate of 1,600 gallons per location will be applied. • Approximately 4,800 gallons of material required. • Duration for injection and process monitoring: 3 months.
Full-Scale Application: Injection points to be placed to deliver reagents to the perched groundwater zone. Treatment criterion is to be based on PSSRGs (Table 2.1).	• Assume 15-foot ROI per injection point, and 100 injection locations. • 3 injection events (1 month period between events). • Each event to be completed in 50 days. • Assume Fenton's reagent dose rate of 1,600 gallons per location (dose adjusted for volume as determined by the pilot study). • Approximately 480,000 gallons of material required. • Duration for injection and process monitoring: 6-9 months.
Monitoring Well Network: Required to track performance of ISCO and assure compliance with treatment criteria. Wells situated mostly within plume and western perimeter since the hydraulic gradient is inconsistent.	Perched Zone: 8 wells, 2-inch diameter, Schedule 40 PVC, screened 20 to 35 ft bgs. Some injection wells would be converted for use as monitoring wells.
Estimated Project Duration (pilot + full-scale): 1 year + minimum of 5 years monitoring.	Approximately 6 years.
Conceptual Design Considerations	
• ISCO does not address vadose zone soil contamination. • Consider combining with HVDPE for treatment of vadose zone soil. • Hydraulic or pneumatic fracturing could be used as an enhancement to improve dispersion of oxidizing agents. Efficient use of technology should include "fracing" in the perching clay.	

3.4.2.5 Alternative SP4 – Enhanced *In-situ* Bioremediation

Alternative SP4 – Enhanced *In-situ* Bioremediation *Upper Vadose Soil and Perched Groundwater Remediation Zone*	
Alternative Description	
Enhanced *In-Situ* Bioremediation (EISB) involves injecting the selected organic substrate (electron donor) and collecting and analyzing groundwater samples to monitor the bioremediation process. The contaminant concentrations and general chemistry parameters (selected anions, degradation by-products, and environmental indicators) are documented prior to and following the injection activity. EISB is a method used to degrade chlorinated ethenes using microbiological processes naturally occurring in the substrate environment. The intrinsic microbiological processes are promoted by subsurface injection of organic substrate. Reductive dechlorination is one of the primary attenuation mechanisms by which chlorinated solvent groundwater plumes can be remediated. This process is a subsequent degradation of tetrachloroethene (PCE) to trichloroethene (TCE), TCE to cis-1,2-dichloroethene (cis-1.2-DCE), cis-1,2-DCE to vinyl chloride (VC), and finally VC to ethene. In this manner, the COCs such as TCE can be degraded into harmless compounds such as ethene over time. Hydrogen Release Compound (HRC®) one of the available organic substrates is well documented for accelerating *in-situ* bioremediation rates of chlorinated ethenes via anaerobic reductive dechlorination processes. Reductive dechlorination is not effective for treating compounds (e.g., benzene, toluene) that biodegrade under aerobic conditions; these compounds would have to be addressed aerobically before or after reductive dechlorination. EISB is not recommended for *in-situ* treatment of soil since the mechanics of substrate delivery are unproven and groundwater is required to assist with dispersion. For this reason, EISB would only provide a partial treatment solution to the Upper Vadose Soil and Perched Groundwater Remediation Zone. Pathways to human exposure in upper vadose soils and the potential for migration of COCs would not be addressed.	
Site Characteristics	
Area of Source control:	
Soil Area (based on exceedances of the SSLs and DAF 20):	69,600 ft^2
Approximate Thickness:	32 ft (3 to 35 ft bgs) 37 ft (3 to 40 ft bgs including perching clay)
Volume:	82,500 yd^3 to 95,400 yd^3
Perched Groundwater Area:	168,000 ft^2
Approximate Thickness:	2 to 3 ft (top of perching clay 25 to 35 ft bgs)
Analytical Data:	
Maximum concentration of COCs in Upper Vadose Zone soils:	• Acetone (16,000 µg/kg) • Benzene (4,100 µg/kg) • DCE (400 µg/kg) • Cis-1,2-DCE (3,300 µg/kg) • Ethylbenzene (61,000 µg/kg) • Methylene chloride (530 µg/kg) • PCE (2,000 µg/kg) • Toluene (98,000 µg/kg) • TCE (3,300 µg/kg) • Vinyl chloride (280 µg/kg) • PAHs (630 to 40,000 µg/kg)
Maximum concentration of COCs in Perched Zone groundwater:	• Benzene (1,600 µg/L) • PCE (1,100 µg/L) • TCE (680 µg/L), • cis-1,2-DCE (780 µg/L) • Vinyl chloride (240 µg/L) • 1,4-dioxane (920 µg/L)

Alternative SP4 – Enhanced *In-situ* Bioremediation (cont'd) *Upper Vadose Soil and Perched Groundwater Remediation Zone*	
Site Characteristics (cont'd)	
Analytical Data:	
Average levels of major environmental indicators (oxygen, nitrate, and sulfate) in the Perched Zone:	0.8 mg/L, 4.1 mg/L, and 157 mg/L, respectively (assumed from 'A ' Zone)
Hydrogeologic Data:	
Depth to Perched Zone groundwater:	20 to 30 feet bgs.
Direction/gradient of groundwater flow in Perched Zone:	Inconsistent due to perching clay
Miscellaneous: Residential neighborhoods are situated to the south of the site.	
Conceptual Design Components and Assumptions	
Component	**Assumptions**
Analytical and Hydrogeologic Data: Potential sulfate reduction demand <490 µg/L. General anaerobic groundwater geochemistry with oxygen <2.2 mg/L, nitrate <40 mg/L, and oxidation-reduction potential between –116 mV and 225 mV.	Suitable geochemistry for use.
Pilot Test: An EISB pilot test would refine design parameters prior to full-scale implementation. Baseline sampling (one-time event) prior to injection activity and an estimated 3 sampling events following injection activity is expected over the 6-month pilot study period. Parameters to be monitored for long-term treatment monitoring include: COCs (chlorinated ethenes), field parameters (DO, ORP, pH, and temperature), biodegradation parameters (nitrate, sulfate, sulfide, chloride, ferrous iron, and alkalinity), substrate fermentation products (total organic carbon and metabolic acids), and biodegradation end products (carbon dioxide, methane, ethane, and ethene).	• Test area: 900 s.f. x 50 ft thick • Assume 9 injection points with minimum of 0.625-inch inner diameter. • Assume 10-foot radius of influence per injection point, 10-foot saturated thickness. • HRC® dose rate of 8.0 lbs per vertical ft (80 lbs per point). • Duration for injection and process monitoring: 6 months.
Full-Scale Application: Injection points to be placed to deliver reagents to the perched groundwater zone. Treatment criterion is to be based on PSSRGs (Table 2.1).	• Assume 200 injection points with minimum of 0.625-inch inner diameter. • Ten direct push borings per day (5 week completion). • Assume 10 to 15-foot radius of influence per injection point; varying thicknesses. • HRC® dose rate in the range of 18 to 20 lbs per vertical foot (assume 280 lbs per point). Possibly in two applications. • Duration for injection and process monitoring: 6 months.
Monitoring Well Network: Required to track performance of EISB and assure compliance with treatment criteria. Wells situated mostly within perched zone plume since the hydraulic gradient is inconsistent.	• Perched Zone: 8 wells, 2-inch diameter, Schedule 40 PVC, screened 20 to 35 ft bgs.
Monitoring/Reporting Frequency: Reporting will be performed in compliance with permits and to document contaminant removal rates, flows, cleanup forecasts, and groundwater gradient maps, in appropriate frequency to data collection.	• Baseline sampling (one-time event) prior to injection activity. • Semiannual sampling events following injection activity. • Parameters to be monitored identical to pilot study (see above). • QA/QC Program Plan for the sampling plan.
Estimated Project Duration (pilot + full-scale): 1 year + minimum of 5 years monitoring.	Approximately 6 years.

Alternative SP4 – Enhanced *In-situ* Bioremediation (cont'd)
Upper Vadose Soil and Perched Groundwater Remediation Zone

Conceptual Design Considerations

- Monitoring program can be reevaluated after 5 years for potential of sampling location or frequency reduction.
- Delivery locations may need to be adjusted to take into account site features such as underground utilities and other site structures.
- Due to specific physical characteristics of HRC® material, pressure required for delivery to the subsurface ranges from 200 psig to 1,500 psig, for which Rupe ORC/HRC 9-1500 and the Geoprobe GS-2000 pumps are recommended by Regenesis – the HRC® material producer.
- Design is for a one-time application of HRC®; the need for re-application will primarily depend on site-specific biodegradation performance. If required, re-application will be applied over the reduced area and dose amount compared to the initial application.
- Consider combining with HVDPE for treatment of the vadose zone soil.
- Hydraulic or pneumatic fracturing could be used as an enhancement to improve dispersion of HRC®. Efficient use of technology should include "fracing" in the perching clay.

3.4.2.6 Alternative SP5 – Monitored Natural Attenuation

Alternative SP5 – Monitored Natural Attenuation[1] (MNA) *Upper Vadose Soil and Perched Groundwater Remediation Zone*	
Alternative Description	
Monitored Natural Attenuation (MNA) consists only of collecting and analyzing groundwater samples and hydraulic data to document and/or model the persistence of contaminant concentrations or their natural attenuation. Natural attenuation differs from 'No Action' because it requires that supporting documentation, including groundwater monitoring results and modeling predictions, be supplied to demonstrate that contaminant concentrations can be reduced to cleanup levels in a reasonable timeframe. Chlorinated and BTEX compounds (Site COCs) are amenable to natural attenuation in groundwater provided that characteristic environmental conditions and intrinsic microbiological processes are present. The natural attenuation processes include biodegradation, dispersion, dilution, sorption, volatilization, and chemical or biological stabilization, transformation, or destruction of contaminants, i.e., chlorinated solvents. MNA is not practical in the unsaturated zone and is best when combined with a source control option since it does not actively affect mobility, toxicity, or volume. MNA would not eliminate the potential for migration of COCs in this remediation zone nor the pathways to human exposure to COCs without the addition of a more aggressive remedial alternative.	
Site Characteristics	
Area of Source control:	
Soil Area (based on exceedances of the SSLs and DAF 20):	69,600 ft^2
Approximate Thickness:	32 ft (3 to 35 ft bgs) 37 ft (3 to 40 ft bgs including perching clay)
Volume:	82,500 yd^3 to 95,400 yd^3
Perched Groundwater Area:	168,000 ft^2
Approximate Thickness:	2 to 3 ft (top of perching clay 25 to 35 ft bgs)
Analytical Data:	
Maximum concentration of COCs in Upper Vadose Zone soils:	• Acetone (16,000 µg/kg) • Benzene (4,100 µg/kg) • DCE (400 µg/kg) • Cis-1,2-DCE (3,300 µg/kg) • Ethylbenzene (61,000 µg/kg) • Methylene chloride (530 µg/kg) • PCE (2,000 µg/kg) • Toluene (98,000 µg/kg) • TCE (3,300 µg/kg) • Vinyl chloride (280 µg/kg) • PAHs (630 to 40,000 µg/kg)
Maximum concentration of COCs in Perched Zone groundwater:	• Benzene (1,600 µg/L) • PCE (1,100 µg/L) • TCE (680 µg/L), • cis-1,2-DCE (780 µg/L) • Vinyl chloride (240 µg/L) • 1,4-dioxane (920 µg/L)
Average levels of major environmental indicators (oxygen, nitrate, and sulfate) in the Perched Zone:	1.1 mg/L, 2.4 mg/L, and 131 mg/L, respectively
TOC range and pH range are:	3.2 to 100 mg/L and 5.6 to 10.7; respectively
Hydrogeologic Data:	
Depth to Perched Zone groundwater:	20 to 30 feet bgs.
Direction and gradient of groundwater flow in Perched Zone:	Inconsistent due to perching clay
Miscellaneous: Residential neighborhoods are situated to the south of the site.	

Alternative SP5 – Monitored Natural Attenuation (cont'd) *Upper Vadose Soil and Perched Groundwater Remediation Zone*	
Conceptual Design Components and Assumptions	
Component	**Assumptions**
General: MNA is only practical as a containment option when combined with a source control option.	Removal of free product and source areas must be performed.
Monitoring Well Network: To be established to assess potential migration of contaminants and reduction in concentrations. Wells would be situated mostly within the plume and western perimeter of the perched zone since the hydraulic gradient is inconsistent.	• Perched Zone: 8 wells, 2-inch diameter, Schedule 40 PVC, screened 20 to 35 ft bgs
Monitoring/Reporting Frequency: Reporting will be performed to document contaminant removal rates, cleanup forecasts, and groundwater gradient maps, in appropriate frequency to data collection. Parameters to be monitored include: COCs (chlorinated ethenes), field parameters (DO, ORP, pH, and temperature), biodegradation parameters (nitrate, sulfate, sulfide, chloride, ferrous iron, and alkalinity), substrate fermentation products (total organic carbon and metabolic acids), and biodegradation end products (carbon dioxide, methane, ethane, and ethene).	• Semiannual sampling events are recommended. • QA/QC Program Plan will be provided for the Sampling Plan.
Estimated Project Duration:	Approximately 50 years.
Conceptual Design Considerations	
• MNA does not address vadose zone soil contamination and requires combining with a source control alternative for soil. • Monitoring program can be reevaluated after 5 years for potential of sampling location or frequency reduction.	

[1] Reference Technical Memorandum: Pemaco Data Evaluation for Natural Attenuation and Biodegradation of Chlorinated Ethenes (TN&A, January 2003), which is provided as Appendix F.

3.4.3 Alternatives for Lower Vadose Soil and Exposition Groundwater (35 to 100 ft bgs) Remediation Zone

The Lower Vadose Soil and Exposition Groundwater Remediation Zone poses risks of human exposure to future onsite residents by direct contact (inhalation, ingestion, and/or dermal contact) with groundwater containing COCs. Five remediation alternatives were identified to reduce these risks during the screening of process options and remedial alternatives for lower vadose soils and the Exposition ‘A’ and ‘B’ groundwater zones. The assembled alternatives also address 1) the continued migration of COCs from the source area (highly contaminated lower vadose soils) to Exposition groundwater zones, 2) the further migration of COCs to adjacent properties and potential migration to local production wells, and 3) groundwater restoration per the State of California Antidegradation Policy (SWRCB Resolution No. 68-16).

The five remedial alternatives assembled for the lower vadose zone soil and Exposition groundwater remediation zone address both source reduction and containment. This was necessary due to the large discrepancy between the source area (69,400 ft^2) and the entire dissolved-phase plume area (550,000 ft^2). As the original sources (e.g., drums, USTs) are no longer present on the site, “source areas” are considered areas of heavily contaminated media (namely lower vadose zone soils) that have free product or high concentrations of residual contamination. The source area within this remediation zone was delineated during RI activities and is represented as the area within the 1,000 µg/L TCE contour of the Exposition ‘A’ and ‘B’ composite plume illustrated in Figure 15. The following remedial alternatives focus on treatment of this source area.

3.4.3.1 Alternative SG1 – No Action

As required by the NCP, the “No Action” alternative must be included as a remedial alternative to provide a baseline for evaluation of the remedial process options.

The No Action alternative does not involve any proactive treatment, removal, or monitoring of the contaminated media. In the Lower Vadose Soil and Exposition Groundwater Remediation Zone (35 to 100 ft bgs), VOCs exist at concentrations above the U.S. EPA Region IX PRGs and USEPA and CalEPA MCLs, respectively. If not addressed, lower vadose soils will continue to act a source for the Exposition groundwater zones. A pathway for human exposure may eventually exist if groundwater contamination spreads towards domestic production wells; the shallowest well is located approximately 4,000 ft downgradient of the site and is screened beginning at 350 ft bgs. Therefore, No Action for the Lower Vadose Soil and Exposition Groundwater Remediation Zone would not be protective of human health as residents may be exposed to COCs. In addition, groundwater quality would not be restored to ARARs and/or local background.

3.4.3.2 Alternative SG2 – *In-situ* Chemical Oxidation/*In-situ* Chemical Reduction/ Groundwater Pump and Treat/Monitored Natural Attenuation/Ultraviolet Oxidation

Alternative SG2 – *In-situ* Chemical Oxidation/*In-situ* Chemical Reduction/ Groundwater Pump and Treat/Monitored Natural Attenuation/Ultraviolet Oxidation
Lower Vadose Soil and Exposition Groundwater Remediation Zone

Alternative Description

Under this alternative, ISCO and ISCR would be used in combination, series, or individually (based on treatability study results) to treat higher concentrations of contaminants within the 1,000 ppb composite groundwater plume contour. Groundwater pump and treat (P&T) would be used between the 1,000 and 10 ppb composite groundwater plume contour to provide hydraulic control and to facilitate dispersion of oxidizing/reducing agents similar to a recirculation cell. (Extracted groundwater would be treated via UV oxidation.) MNA would be used outside the 10 ppb composite plume to demonstrate plume reduction and/or point of compliance.

ISCO and ISCR involve injecting select oxidizing/reducing agents into the subsurface and collecting/analyzing groundwater samples to monitor the degradation process. The contaminant concentrations (i.e., chlorinated ethenes), general chemistry parameters pertinent to the process (i.e., total organic carbon, peroxide, chloride, sulfate, manganese, and ferrous iron) and environmental indicators (i.e., pH, specific conductivity, oxidation-reduction potential, and turbidity) are documented prior to and following the injection events. Long-term monitoring includes additional parameters such as natural attenuation indicators (i.e., dissolved gases and selected anions). ISCO and ISCR are not recommended for *in-situ* treatment of unsaturated soil since the mechanics of substrate delivery are unproven and groundwater is required to assist with dispersion.

To determine the effectiveness of either ISCO or ISCR, the optimal spacing between injection points, and the amount of oxidizing/reducing agent needed, a treatability study would be performed prior to full-scale application. ISCO and ISCR have identical delivery methods (via well), and similar costs. The treatability study results would be used to determine whether both technologies or just one would be applied.

Site Characteristics	
Area of Source Control:	
'A' and 'B' Exposition groundwater zones:	69,400 ft^2 (within the 1,000 ppb contour)
Analytical Data:	
Maximum concentration of Primary COCs in 'A' Zone:	TCE (27,000 µg/L), cis-1,2-DCE (2,600 µg/L) and VC (100 µg/L)
Maximum concentration of Primary COCs in 'B' Zone:	TCE (21,000 µg/L), cis-1,2-DCE (14,000 µg/L) and VC (780 µg/L)
Average level of total organic carbon in 'A' Zone:	4.9 mg/L
Average level of total organic carbon in 'B' Zone:	56 mg/L
Range of pH levels in Exposition groundwater zones:	6.5 to 7.5
Hydrogeologic Data:	
Depth to groundwater in Exposition Aquifer:	67 ft bgs
Saturated soil thickness:	Approximately 50 ft
Direction and gradient of groundwater flow in 'A' Zone:	0.011 feet/foot, southwest
Direction and gradient of groundwater flow in 'B' Zone:	0.009 feet/foot, west-southwest
Hydraulic conductivity (average for 'A' Zone):	1.46E-03 ft/min
Hydraulic conductivity (average for 'B' Zone):	3.27E-02 ft/min

Alternative SG2 – *In-situ* Chemical Oxidation/*In-situ* Chemical Reduction/ Groundwater Pump and Treat/Monitored Natural Attenuation/Ultraviolet Oxidation/ (cont'd) *Lower Vadose Soil and Exposition Groundwater Remediation Zone*	
Conceptual Design Components and Assumptions	
Component	**Assumptions**
Bench Test: Collection of one sample per zone (total of 3 samples) to determine the actual volume of the oxidizing/reducing agent required per injection location for contaminant oxidation/reduction and complete degradation.	• For ISCO: Fenton's reagent or a permanganate solution would be applied due to the high contamination levels and complexity of site hydrogeology. • For ISCR: a proprietary zero-valent iron solution would be used • Bench test to determine reagent volume.
Pilot Test: An ISCO and ISCR pilot test would confirm project feasibility and design parameters prior to full-scale implementation. Baseline sampling (one-time event) prior to injection activity, one sampling event following each injection event, and one follow-up sampling event after several weeks. Parameters to be monitored include: COCs (chlorinated ethenes), field parameters (pH, specific conductivity, ORP, and turbidity), and general chemistry parameters (total organic carbon, peroxide, chloride, sulfate, manganese, and ferrous iron). Enhancement of both applications would be observed by first fracturing the formation at one of the injection locations (per pilot test). (Note that complications can arise below the water table where fracing borehole cannot stay open long enough for injection tools to re-enter boring.)	• Treatment area: approx. 3,000 ft^2; 50 ft thick. • Assume 15-foot radius of influence per injection point, and 3 injection locations per pilot test, and one injection event. • Install three monitoring wells, in addition to existing. • For ISCO: Assume the oxidant and dose rate will be determined by the bench test. Since Fenton's reagent is the most aggressive, assume for the purposes of the conceptual 3,200 gallons (based on Fenton's dose rate) per location will be applied. • Approximately 9,600 gallons of material required. Duration for injection and process monitoring: 3 months. • For ISCR: Estimated solution dose rate (based on FEROX^{sm}) of 13,000 lbs per injection location, to be adjusted according to the bench test, for a total of 39,000 lbs. • Duration for injection and process monitoring: 6 months

Alternative SG2 – *In-situ* Chemical Oxidation/*In-situ* Chemical Reduction/ Groundwater Pump and Treat/Monitored Natural Attenuation/Ultraviolet Oxidation/ (cont'd) *Lower Vadose Soil and Exposition Groundwater Remediation Zone*	
Conceptual Design Components and Assumptions	
Component	**Assumptions**
Full-Scale Application: It is assumed that permanent injection wells would be placed within the 1,000 ppb groundwater composite TCE plume contour. Reagents will be delivered throughout the Exposition 'A' and 'B' zones. The pilot study results would be used to select the most applicable oxidizing/reducing agent to inject. Since the delivery mechanisms are the same the conceptual design and cost estimate is not significantly affected by leaving the selection of reagents open until the pilot study data is reviewed. Well network design is based on pump test data (average width of capture of 45 ft along downgradient axis; average width of capture of 69 ft along cross-gradient axis). Between the 1,000 and 10 ppb contour: Fifteen (15) P&T wells will be installed in three networks: wells screened in the 'A' Zone, wells screened in the 'B' Zone, and wells screened continuously through the 'A' and 'B' Zones. System flow of 44 gpm (2.0 gpm x [3] 'A' and [3] 'B' wells; 4.0 gpm x [9] 'A' and 'B' wells. To prevent the potential for cross contamination between the different Exposition Zones, the wells screened continuously through the 'A' and 'B' Zones are located outside the 100 ppb plume contour line. Outside the 10 ppb contour MNA would be used outside the 10 ppb composite plume to demonstrate plume reduction and/or point of compliance.	• Assume 98 injection locations – 2in PVC wells. • Assume 2 injection events (1 month period between events). • Each event to be completed in 50 days. • Assume 15-foot radius of influence per injection point. • Reagent dose rate adjusted for volume/weight as determined by the pilot study. • Duration for injection and process monitoring: 6-9 months. • P&T wells to be situated predominantly on the downgradient edge of the source area and along public right-of-ways. • All P&T piping systems would be placed in a trench network. • All P&T wells shall be 6-inch diameter, Schedule 80 PVC. A 0.5 hp submersible pump will be installed in each well. • 'A' Zone: 3 wells, Schedule 80 PVC, screened 65 to 75 ft bgs. • 'B' Zone: 3 wells, Schedule 80 PVC, screened 80 to 100 ft bgs. • 'A' and 'B' Zone: 9 wells Schedule 80 PVC, screened 65 to 100 ft bgs.
Groundwater Treatment System: UV oxidation was selected based on ability to meet treatment discharge requirements. A fenced and covered treatment compound would be mounted on a 20 ft by 30 ft concrete pad with containment foundation (to be shared with vapor treatment). Handling and storage of hydrogen peroxide requires special safety precautions. Electrical service and remote monitoring communication system would be tied into local services with possible back-up power generation. High turbidity, oil and grease, or metal ions would cause interference with UV treatment. It is assumed that typical pretreatment (filtration) for turbidity would be performed.	• Design flow and influent conc. are 50 gpm and 5.0 ppm total VOC • Treatment criterion is to be based on PSSRGs (Table 2.1). • Treatment system influent and effluent to be sampled daily during 7-day startup; quarterly after documented stabilization; semiannually after established trend or continued stabilization. Effluent sampling frequency would be determined by discharge permit. • Long-term O&M plan to be implemented for treatment system. • Influent trench and pipe = 1,200 ft Effluent trench and pipe = 500 ft
Monitoring Well Network: Required for MNA and to track performance of ISCO/ISCR and assure compliance with treatment criteria. Wells within each network (Exposition 'A' and 'B' Zones) will be situated to characterize conditions upgradient and downgradient of the injection locations; and upgradient, downgradient, within the plume, and lateral extent of the plume.	• 'A' Zone: 10 wells, 2-inch diameter, Schedule 40 PVC, screened 65 to 75 ft bgs. • 'B' Zone: 10 wells, 2-inch diameter, Schedule 40 PVC, screened 80 to 100 ft bgs. • 'C' Zone: 5 existing wells shall be used as needed.

Alternative SG2 – *In-situ* Chemical Oxidation/*In-situ* Chemical Reduction/ Groundwater Pump and Treat/Monitored Natural Attenuation/Ultraviolet Oxidation/ (cont'd)
Lower Vadose Soil and Exposition Groundwater Remediation Zone

Conceptual Design Components and Assumptions

Component	Assumptions
Monitoring/Reporting Frequency: Reporting will be performed in compliance with permits and to document contaminant removal rates, flows, cleanup forecasts, and groundwater gradient maps, in appropriate frequency to data collection. Parameters to be analyzed for oxidation/reduction process monitoring are same as pilot study (see above).	• Baseline sampling (one-time event) prior to injection activity. • Semiannual sampling events following the completion of the injection process. • A limited amount of additional sampling after each injection event would be performed for ISCO. • Reporting upon completion of each sampling event. • O&M not anticipated.
Estimated Project Duration (pilot + full-scale): 1 year ISCO/ISCR and P&T + minimum of 5 years monitoring and P&T.	Approximately 6 years.

Conceptual Design Considerations

- Monitoring program can be reevaluated after 5 years for potential of sampling location or frequency reduction.
- Delivery locations may need to be adjusted to take into account site features such as underground utilities and other site structures.
- Upon supplementing groundwater and hydrologic data for the 'C' Zone, a determination for either continued monitoring or monitoring and treatment will be made.
- Potential additional injections of oxidizing agents (Fenton's or permanganate) or reducing agents (zero valent iron solution) can be considered; the need for re-application will primarily depend on site-specific degradation performance. If required, re-application will be applied over the reduced area and dose amount compared to the initial application.
- Fracturing the formation prior to an injection event may enhance treatment, as determined by the pilot study.

3.4.3.3 Alternative SG3 - Enhanced *In-situ* Bioremediation/Groundwater Pump and Treat/Monitored Natural Attenuation/Ultraviolet Oxidation

Alternative SG3 – Enhanced *In-situ* Bioremediation/Groundwater Pump and Treat/ Monitored Natural Attenuation/Ultraviolet Oxidation

Lower Vadose Soil and Exposition Groundwater Remediation Zone

Alternative Description

Under this alternative, EISB would be used, based on treatability study results, to treat higher concentrations of contaminants within the 1,000 ppb composite plume contour. P&T would be used between the 1,000 and 10 ppb composite plume contour to provide hydraulic control and to facilitate dispersion of organic substrate, similar to a recirculation cell. (Extracted groundwater would be treated via UV oxidation.) MNA would be used outside the 10 ppb composite plume to demonstrate plume reduction and/or point of compliance.

EISB involves injecting the selected organic substrate (electron donor) and collecting and analyzing groundwater samples to monitor the bioremediation process. The contaminant concentrations and general chemistry parameters (selected anions, degradation by-products, and environmental indicators) are documented prior to and following the injection activity. EISB is a method used to degrade chlorinated ethenes using microbiological processes naturally occurring in the substrate environment. The intrinsic microbiological processes are promoted by subsurface injection of organic substrate. Reductive dechlorination is one of the primary attenuation mechanisms by which chlorinated solvent groundwater plumes can be remediated. This process is a subsequent degradation of tetrachloroethene (PCE) to trichloroethene (TCE), TCE to cis-1,2-dichloroethene (cis-1.2-DCE), cis-1,2-DCE to vinyl chloride (VC), and finally VC to ethene. In this manner, the COCs such as TCE can be degraded into harmless compounds such as ethene over time. Hydrogen Release Compound (HRC®) one of the available organic substrates is well documented for accelerating *in-situ* bioremediation rates of chlorinated ethenes via anaerobic reductive dechlorination processes. Reductive dechlorination is not effective for treating compounds (e.g., benzene, toluene) that biodegrade under aerobic conditions; these compounds would have to address aerobically before or after reductive dechlorination.

EISB is not recommended for *in-situ* treatment of soil since the mechanics of substrate delivery are unproven and groundwater is required to assist with dispersion. For this reason, EISB would only provide a partial treatment solution to the Lower Vadose Soil and Exposition Groundwater Remediation Zone.

Site Characteristics

Area of Source control:	
'A' and 'B' Exposition groundwater zones:	69,400 ft^2 (within 1,000 ppb contour)
Analytical Data:	
Maximum concentration of Primary COCs in 'A' Zone:	TCE (27,000 µg/L), cis-1,2-DCE (2,600 µg/L) and VC (100 µg/L)
Maximum concentration of Primary COCs in 'B' Zone:	TCE (21,000 µg/L), cis-1,2-DCE (14,000 µg/L) and VC (780 µg/L)
Average levels of major environmental indicators (oxygen, nitrate, and sulfate) in the 'A' Zone:	0.8 mg/L, 4.1 mg/L, and 157 mg/L, respectively
Average levels of major environmental indicators (oxygen, nitrate, and sulfate) in the 'B' Zone:	0.5 mg/L, 0.2 mg/L, and 210 mg/L, respectively
Hydrogeologic Data:	
Depth to groundwater in Exposition Aquifer:	67 ft bgs
Saturated Soil Thickness:	50 ft
Direction and gradient of groundwater flow in 'A' Zone:	0.011 feet/foot, southwest
Direction and gradient of groundwater flow in 'B' Zone:	0.009 feet/foot, west-southwest
Hydraulic conductivity (average for 'A' Zone):	1.46E-03 ft/min
Hydraulic conductivity (average for 'B' Zone):	3.27E-02 ft/min

Alternative SG3 – Enhanced *In-situ* Bioremediation/Groundwater Pump and Treat/ Monitored Natural Attenuation/Ultraviolet Oxidation *Lower Vadose Soil and Exposition Groundwater Remediation Zone*	
Site Characteristics	
Receptors:	
Most shallow well used for domestic production:	Located approx. 4,000 ft southwest of site; screen interval begins at 350 feet bgs.
Closest well used for domestic production:	Located approx. 2,600 ft southwest of site; screen interval begins at 610 feet bgs.
Residential neighborhoods:	Located to the south and downgradient
Conceptual Design Components and Assumptions	
Component	**Assumptions**
Analytical and Hydrogeologic Data: Potential sulfate reduction demand <490 µg/L. General anaerobic groundwater geochemistry with oxygen <2.2 mg/L, nitrate <40 mg/L, and oxidation-reduction potential between –116 mV and 225 mV.	• Estimated groundwater velocity: up to 0.5 ft/day
Pilot Test: An EISB pilot test would refine design parameters prior to full-scale implementation. Baseline sampling (one-time event) prior to injection activity and an estimated 4 sampling events following injection activity is expected over the 6-month pilot study period. Parameters to be monitored for long-term treatment monitoring include: COPCs (chlorinated ethenes), field parameters (DO, ORP, pH, and temperature), biodegradation parameters (nitrate, sulfate, sulfide, chloride, ferrous iron, and alkalinity), substrate fermentation products (total organic carbon and metabolic acids), and biodegradation end products (carbon dioxide, methane, ethane, and ethene).	• Test area: 900 s.f. x 50 ft thick • Assume 9 injection wells, 2-in. diameter, schedule 40 PVC. • Assume 15-foot radius of influence per injection point. • HRC® dose rate of 8.0 lbs per vertical ft (400 lbs per point). • Duration for injection and process monitoring: 6 months.
Full-Scale Application: Injection points to be placed within 1,000 µg/L TCE contour to deliver substrate to Exposition 'A' and 'B' Zones. Duration for injection and process monitoring: 6 to 9 months. Well network design is based on pump test data (average width of capture of 45 ft along downgradient axis; average width of capture of 69 ft along cross-gradient axis). <u>Between the 1,000 and 10 ppb contour:</u> Fifteen (15) P&T wells will be installed in three networks: wells screened in the 'A' Zone, wells screened in the 'B' Zone, and wells screened continuously through the 'A' and 'B' Zones. System flow of 44 gpm (2.0 gpm x [3] 'A' and [3] 'B' wells; 4.0 gpm x [9] 'A' and 'B' wells. To prevent the potential for cross contamination between the different Exposition Zones, the wells screened continuously through the 'A' and 'B' Zones are located outside the 100 ppb plume contour line. <u>Outside the 10 ppb contour</u> MNA would be used outside the 10 ppb composite plume to demonstrate plume reduction and/or point of compliance.	• Assume 98 injection wells, same design as pilot. • Assume 15-foot radius of influence per injection point. • HRC® dose rate in the range of 18 to 20 lbs per vertical foot or approximately 910 lbs per point. Possibly in two applications. • Total HRC® requirement is approximately 89,180 lbs. • P&T wells to be situated predominantly on the downgradient edge of the source area and along public right-of-ways. • All P&T piping systems would be placed in a trench network. • All P&T wells shall be 6-inch diameter, Schedule 80 PVC. A 0.5 hp submersible pump will be installed in each well. • 'A' Zone: 3 wells, Schedule 80 PVC, screened 65 to 75 ft bgs. • 'B' Zone: 3 wells, Schedule 80 PVC, screened 80 to 100 ft bgs. • 'A' and 'B' Zone: 9 wells Schedule 80 PVC, screened 65 to 100 ft bgs.

<table>
<tr><th colspan="2">Alternative SG3 – Enhanced In-situ Bioremediation/Groundwater Pump and Treat/
Monitored Natural Attenuation/Ultraviolet Oxidation
Lower Vadose Soil and Exposition Groundwater Remediation Zone</th></tr>
<tr><th colspan="2">Conceptual Design Components and Assumptions</th></tr>
<tr><th>Component</th><th>Assumptions</th></tr>
<tr><td>Monitoring Well Network: Required to track performance of EISB and assure compliance with treatment criteria. Wells within each network (Exposition ‘A’, and ‘B’ Zones) will be situated to characterize conditions upgradient and downgradient of the injection locations; and upgradient, downgradient, within the plume, and lateral extent of the plume.</td><td>• ‘A’ Zone: 10 wells, 2-inch diameter, Schedule 40 PVC, screened 65 to 75 ft bgs.
• ‘B’ Zone: 10 wells, 2-inch diameter, Schedule 40 PVC, screened 80 to 100 ft bgs.
• ‘C’ Zone: 5 existing wells shall be used as needed.</td></tr>
<tr><td>Monitoring/Reporting Frequency: Reporting will be performed in compliance with permits and to document contaminant removal rates, flows, cleanup forecasts, and groundwater gradient maps, in appropriate frequency to data collection. QA/QC Program Plan to be included for the sampling plan.</td><td>• Baseline sampling (one-time event) prior to injection activity.
• Semiannual sampling events following injection activity.
• Parameters to be monitored identical to pilot study (see above).</td></tr>
<tr><td>Estimated Project Duration (pilot + full-scale): 1 year EISB and P&T + minimum of 5 years monitoring and P&T.</td><td>Approximately 6 years.</td></tr>
<tr><th colspan="2">Conceptual Design Considerations</th></tr>
<tr><td colspan="2">• Monitoring program can be reevaluated after 5 years for potential of sampling location or frequency reduction.
• Delivery locations may need to be adjusted to take into account site features such as underground utilities and other site structures.
• Due to specific physical characteristics of HRC® material, pressure required for delivery to the subsurface ranges from 200 psig to 1,500 psig, for which Rupe ORC/HRC 9-1500 and the Geoprobe GS-2000 pumps are recommended by Regenesis – the HRC® material producer.
• Design is for a one-time application of HRC®; the need for re-application will primarily depend on site-specific biodegradation performance. If required, re-application will be applied over the reduced area and dose amount compared to the initial application.
• Fracturing the formation prior to an injection event may enhance treatment, as determined by the pilot study.</td></tr>
</table>

3.4.3.4 Alternative SG4a – Vacuum-Enhanced Groundwater Extraction/Pump and Treat/Monitored/Monitored Natural Attenuation/Ultraviolet Oxidation/Flameless Thermal Oxidation

<table>
<tr><th colspan="2">Alternative SG4a – Vacuum-Enhanced Groundwater Extraction/Pump and Treat/
Monitored Natural Attenuation/Ultraviolet Oxidation/
Flameless Thermal Oxidation and Granular Activated Carbon
Lower Vadose Soil and Exposition Groundwater Remediation Zone</th></tr>
<tr><th colspan="2">Alternative Description</th></tr>
<tr><td colspan="2">Under this alternative, vacuum-enhanced groundwater extraction would be performed on all wells within the 1,000 ppb composite plume contour source area to treat dissolved phase contaminants and free product. Between the 1,000 ppb and 10 ppb composite plume contour, typical P&T wells would be used to achieve hydraulic control of the dissolved contaminant plume. MNA would be used outside the 10 ppb composite plume to demonstrate plume reduction and/or point of compliance. The contaminated groundwater and soil vapor would be transported to separate above ground treatment systems where the contaminants would be removed prior to discharge. UV Ox would be used for groundwater treatment and flameless thermal oxidation (FTO) and GAC would be used for vapor treatment. Both UV Ox and FTO would completely destroy all COCs on-site with no residual wastes to manage. After one year of remediation, the vapor treatment system would be switched to GAC - a more cost effective option for lower contaminant loading. The treated groundwater could be disposed by reinjection back into the aquifer, discharged to the sanitary sewer, or discharged to the LA River depending on permit approval. The treated soil vapor would discharge to the air above the site.

This alternative assumes that that initial high mass loading of VOCs extracted during the first year of operation would be more effectively and efficiently treated using FTO. Due to the 99.9% destruction effectiveness rate of FTO, the production of combustion by-products (e.g., dioxin) above background concentrations is unlikely. After the first year, it is estimated that the mass loading will be significantly reduced and switching to a GAC vapor treatment system would be more cost effective.

GAC absorbs COCs from the extracted vapor for later disposal at an off-site approved facility. GAC is not an effective method of treatment for low molecular weight VOCs, such as vinyl chloride, or COCs with low adsorptive capacity, such as 1,4-dioxane. However, it is estimated that a significant proportion of these two contaminants would be eliminated in the first year to allow for treatment via GAC. Further evaluation of the proportion of low molecular weight VOCs in the vapor stream would be necessary prior to implementing GAC vapor treatment.

In the area of highest contamination (within 1,000 ppb contour), drawdown caused by groundwater extraction exposes well screen area from which soil vapor can be extracted, via surface blowers. As the soil vapor is extracted (under vacuum), it removes VOC contaminants trapped in the soil pores. Groundwater extraction coupled with high vacuum vapor extraction allow for good control over contaminant mobility and a reduction in contaminant volume (onsite) through extraction of liquid phase and gas phase contaminants. Enhanced P&T with vapor extraction would effectively eliminate the potential for migration of COCs in this remediation zone and the pathways to human exposure for COCs the Exposition groundwater zones.</td></tr>
<tr><th colspan="2">Site Characteristics</th></tr>
<tr><td>Area of Source control:</td><td></td></tr>
<tr><td align="right">‘A’ and ‘B’ Exposition groundwater zones:</td><td>69,400 ft^2 (within the 1,000 ppb contour)</td></tr>
<tr><td>Analytical Data:</td><td></td></tr>
<tr><td align="right">Maximum concentration of Primary COCs in ‘A’ Zone:</td><td>TCE (27,000 µg/L), cis-1,2-DCE (2,600 µg/L) and VC (100 µg/L)</td></tr>
<tr><td align="right">Maximum concentration of Primary COCs in ‘B’ Zone:</td><td>TCE (21,000 µg/L), cis-1,2-DCE (14,000 µg/L) and VC (780 µg/L)</td></tr>
</table>

<table>
<tr><th colspan="2">Alternative SG4a – Vacuum-Enhanced Groundwater Extraction/Pump and Treat/
Monitored Natural Attenuation/Ultraviolet Oxidation/
Flameless Thermal Oxidation and Granular Activated Carbon (cont'd)
Lower Vadose Soil and Exposition Groundwater Remediation Zone</th></tr>
<tr><th colspan="2">Site Characteristics</th></tr>
<tr><td>Hydrogeologic Data:</td><td></td></tr>
<tr><td>Depth to groundwater in Exposition Aquifer:</td><td>67 ft bgs</td></tr>
<tr><td>Direction and gradient of groundwater flow in 'A' Zone:</td><td>0.011 feet/foot, southwest</td></tr>
<tr><td>Direction and gradient of groundwater flow in 'B' Zone:</td><td>0.009 feet/foot, west-southwest</td></tr>
<tr><td>Hydraulic conductivity (average for 'A' Zone):</td><td>1.46E-03 ft/min</td></tr>
<tr><td>Hydraulic conductivity (average for 'B' Zone):</td><td>3.27E-02 ft/min</td></tr>
<tr><td>Pump Test Data:</td><td>Average width of capture of 45 ft along downgradient axis; average width of capture of 69 ft along cross-gradient axis</td></tr>
<tr><td>Groundwater Extraction flow rate:</td><td>2 gpm for 'A' and 'B' Zones.</td></tr>
<tr><td>HVDPE Pilot Test Data:</td><td>Vacuum ROI of 54 ft at 68 scfm and
14 in of Hg</td></tr>
<tr><td>Boundary Conditions:</td><td>No documented recharge from LA River</td></tr>
<tr><td>Potential Receptors:</td><td></td></tr>
<tr><td>Most shallow well used for domestic production:</td><td>Located approx. 4,000 ft southwest of site; screen interval begins at 350 feet bgs</td></tr>
<tr><td>Closest well used for domestic production:</td><td>Located approx. 2,600 ft southwest of site; screen interval begins at 610 feet bgs</td></tr>
<tr><td>Residential neighborhoods:</td><td>Located to the south and downgradient.
All homes on municipal water.</td></tr>
<tr><th colspan="2">Conceptual Design Components and Assumptions</th></tr>
<tr><th>Component</th><th>Assumptions</th></tr>
<tr><td>Vacuum-Enhanced and Groundwater Pumping Well Networks: Well network design is based on pump test data (average width of capture of 45 ft along downgradient axis; average width of capture of 69 ft along cross-gradient axis).

<u>Within 1,000 ppb plume contour</u>: Twenty (20) vacuum-enhanced groundwater extraction wells will be installed within the 1,000 ppb contour in two networks: 'A' Zone wells and 'B' Zone wells. System flow of 40 gpm (2.0 gpm x [20] 'A' and 'B' wells). Wells are typical P&T wells to which a vacuum is applied.

<u>Between the 1,000 and 10 ppb contour:</u> Fifteen (15) P&T wells will be installed in three networks: wells screened in the 'A' Zone, wells screened in the 'B' Zone, and wells screened continuously through the 'A' and 'B' Zones. System flow of 44 gpm (2.0 gpm x [3] 'A' and [3] 'B' wells; 4.0 gpm x [9] 'A' and 'B' wells. To prevent the potential for cross contamination between the different Exposition Zones, the wells screened continuously through the 'A' and 'B' Zones are located outside the 100 ppb plume contour line.

<u>Outside the 10 ppb contour</u>
MNA would be used outside the 10 ppb composite plume to demonstrate plume reduction and/or point of compliance.</td><td>• Wells to be situated predominantly in the source area and along public right-of-ways
• All piping systems would be placed in a trench network.
• Assume a blower requirement of 1,500-scfm.
• Groundwater extraction rate is estimated to be 2 gpm for 'A' and 'B' Zones for a total flow of 84 gpm.
• All wells shall be 6-inch diameter, Schedule 80 PVC. A 0.5 hp submersible pump will be installed in each well.
• 'A' Zone: 13 wells, Schedule 80 PVC, screened 65 to 75 ft bgs.
• 'B' Zone: 13 wells, Schedule 80 PVC, screened 80 to 100 ft bgs.
• 'A' and 'B' Zone: 9 wells Schedule 80 PVC, screened 65 to 100 ft bgs. Wells to be situated predominantly in the source area and along public right-of-ways.
• Assumptions are based on HVDPE pilot test. (Refer to Appendix D for the results.)</td></tr>
</table>

Alternative SG4a – Vacuum-Enhanced Groundwater Extraction/Pump and Treat/ Monitored Natural Attenuation/Ultraviolet Oxidation/ Flameless Thermal Oxidation and Granular Activated Carbon (cont'd) *Lower Vadose Soil and Exposition Groundwater Remediation Zone*	
Conceptual Design Components and Assumptions	
Component	**Assumptions**
Groundwater Treatment System: UV oxidation was selected based on ability to meet treatment discharge requirements. A fenced and covered treatment compound would be mounted on a 20 ft by 30 ft concrete pad with containment foundation (to be shared with vapor treatment). Handling and storage of hydrogen peroxide requires special safety precautions. Electrical service and remote monitoring communication system would be tied into local services with possible back-up power generation. High turbidity, oil and grease, or metal ions would cause interference with UV treatment. It is assumed that typical pretreatment (filtration) for turbidity would be performed.	• Design flow and influent conc. are 150 gpm and 6.0 ppm total VOC (includes factor of safety increase). • Treatment criterion is to be based on PSSRGs (Table 2.1). • Treatment system influent and effluent to be sampled daily during 7-day startup; quarterly after documented stabilization; semiannually after established trend or continued stabilization. Effluent sampling frequency would be determined by discharge permit. • Long-term O&M plan to be implemented for treatment system. • Influent trench and pipe = 1,200 ft Effluent trench and pipe = 500 ft
Soil Vapor Treatment System: The selected soil vapor treatment process, FTO for the first year followed by GAC for the remaining years, would be housed in the treatment compound alongside the groundwater treatment system. Treatment criteria will be determined in accordance with the South Coast Air Quality Management District (SCAQMD) discharge permit. Target destruction efficiency would average 99% with concentrations of combustion by-products (e.g., dioxin) below background concentrations during FTO operation and low (approved) concentrations of vinyl chloride and 1,4 dioxane emissions during GAC operation.	• Total design system flow of 1,500 scfm. • Estimated average first year influent vapor concentration of 315 ppm • Treatment system influent and effluent to be sampled daily during 7-day startup; weekly after documented stabilization or trend; quarterly or in accordance with discharge permit thereafter. • Additional monitoring via PID will be performed to supplement sampling data and to schedule timing for switching on-line wells. • Additional monitoring via PID will be performed to supplement sampling data and to schedule timing for switching on-line wells.
Conceptual Design Components and Assumptions	
Component	**Assumptions**
Monitoring/Reporting Frequency: Reporting will be performed to document contaminant removal rates, flows, cleanup forecasts, and groundwater gradient maps, in appropriate frequency to data collection.	• Semiannual groundwater sampling events are recommended. • Annual monitoring may be recommended after demonstration of reduction in plume volume and mobility. • QA/QC Program Plan will be instituted for all sampling and treatment. • Long term O&M plan required.
Estimated Project Duration: 15 years + a minimum of 5 years of groundwater monitoring.	Approximately 20 years.

Alternative SG4a – Vacuum-Enhanced Groundwater Extraction/Pump and Treat/ Monitored Natural Attenuation/Ultraviolet Oxidation/ Flameless Thermal Oxidation and Granular Activated Carbon (cont'd) *Lower Vadose Soil and Exposition Groundwater Remediation Zone*
Conceptual Design Considerations
• This process option would be most cost effective if implemented through the perched zone also. • Enhancements: Hydraulic or pneumatic fracturing could be used as an enhancement for removal of contaminant from source area. Targeted "fracing" zones to be performed only in impermeable lithosomes including 50–65 ft bgs (above the Exposition 'A' Zone) and 74–80 ft bgs (between the 'A' and 'B' groundwater zones). Efficient use of technology should include "fracing" in the perching clay (28–40 ft bgs)

3.4.3.5 Alternative SG4b – Vacuum-Enhanced Groundwater Extraction/Pump and Treat/Monitored Natural Attenuation/Ultraviolet Oxidation/Granular Activated Carbon

Alternative SG4b – Vacuum-Enhanced Groundwater Extraction/ Pump and Treat/ Monitored Natural Attenuation/ Ultraviolet Oxidation/Granular Activated Carbon *Lower Vadose Soil and Exposition Groundwater Remediation Zone*	
Alternative Description	
The treatment process and conceptual design is the same as described in Alternative SG4a with the exception of vapor treatment, which would employ only granular activated carbon (GAC). GAC absorbs COCs from the extracted vapor for later disposal at an off-site approved facility. GAC is not an effective method of treatment for low molecular weight VOCs, such as vinyl chloride, or COCs with low adsorptive capacity, such as 1,4-dioxane. Further evaluation of the proportion of low molecular weight VOCs in the vapor stream would be necessary prior to implementing GAC vapor treatment. Assuming cleanup criteria are met, the treated soil vapor would discharge to the air above the site.	
Site Characteristics	
The Site Characteristics are the same as Alternative SG4a.	
Conceptual Design Components and Assumptions	
Component	**Assumptions**
Vacuum Enhanced and Groundwater Pumping Well Networks: See Alternative SG4a for the Vacuum-Enhanced and Groundwater Pumping Well System.	Same as Alternative SG4a.
Groundwater Treatment System: See Alternative SG4a for the Groundwater Treatment System.	Same as Alternative SG4a.
Soil Vapor Treatment System: The selected soil vapor treatment process, GAC, would be housed in the treatment compound alongside the groundwater treatment system. Treatment criteria will be determined in accordance with the South Coast Air Quality Management District (SCAQMD) discharge permit. Target destruction efficiency would average 99% with low (approved) concentrations of vinyl chloride and 1,4 dioxane emissions during GAC operation.	Same as Alternative SG4a without FTO.
Conceptual Design Components and Assumptions	
Component	**Assumptions**
Monitoring/Reporting Frequency: Reporting would be the same as Alternative SG4a without the FTO system.	• Same as Alternative SG4a with the addition of: • Additional reporting of effluent monitoring data for vinyl chloride and 1,4-dioxane would be performed in accordance with the SCAQMD permit. .
Estimated Project Duration: Same as Alternative SG4a	• Approximately 20 years.
Conceptual Design Considerations	
Same as Alternative SG4a.	

3.4.3.6 Alternative SG5a – Electrical Resistance Heating with Vapor Extraction/Vacuum-Enhanced Groundwater Extraction/Pump and Treat/Monitored Natural Attenuation/Ultraviolet Oxidation/Flameless Thermal Oxidation and Granular Activated Carbon

Alternative SG5a – Electrical Resistance Heating with Vapor Extraction/Vacuum-Enhanced Groundwater Extraction/Pump and Treat/ Monitored Natural Attenuation/Ultraviolet Oxidation/Flameless Thermal Oxidation and Granular Activated Carbon

Lower Vadose Soil and Exposition Groundwater Remediation Zone

Alternative Description

Under this alternative, Electrical Resistance Heating (ERH) with vapor extraction (VE) would be used to treat soil and groundwater within the 10,000 ppb composite plume. Vacuum-enhanced groundwater extraction would be used between the 10,000 ppb and 1,000 ppb composite plume contour. Groundwater Pump and Treat (P&T) would be used between 1,000 ppb and 10 ppb composite plume contour to achieve hydraulic control of the dissolved contaminant plume. MNA would be used outside the 10 ppb composite plume to demonstrate plume reduction and/or point of compliance. The contaminated groundwater and soil vapor would be transported to separate above ground treatment systems where the contaminants are removed prior to discharge. Ultraviolet oxidation (UV Ox) would be used for groundwater treatment and flameless thermal oxidation (FTO) and granular activated carbon (GAC) for vapor treatment. Both UV Ox and FTO would completely destroy all COCs on-site with no residual wastes to manage. After one year of remediation, the vapor treatment system would be switched to GAC - a more cost effective option for lower contaminant loading. The treated groundwater could be disposed by reinjection back into the aquifer, discharged to the sanitary sewer, or discharged to the LA River depending on permit approval. The treated soil vapor would discharge to the air above the site.

ERH utilizes an array comprised of six to nine electrodes that are inserted into the ground to the depth of the contamination. The electrodes heat the soil and groundwater to approximately 100 degrees Celsius via resistive current. Contaminants are volatized and removed from the subsurface from the resulting *in-situ* steam stripping. Volatilized contaminants are collected at the surface via VE. ERH with VE would effectively eliminate the potential for migration and pathways to human exposure of COCs in this remediation zone.

Vacuum-enhanced groundwater extraction would be performed on all wells between the 10,000 and 1,000 ppb composite plume contour. Drawdown caused by groundwater extraction exposes well screen area from which soil vapor can be extracted, via surface blowers. As the soil vapor is extracted (under vacuum), it removes VOC contaminants trapped in the soil pores. Vacuum-enhanced groundwater extraction will allow for good control over contaminant mobility and a reduction in contaminant volume (onsite) through extraction of liquid phase and gas phase contaminants.

This alternative assumes that that initial high mass loading of VOCs extracted during ERH operation would quickly overload a carbon treatment system. Therefore, FTO would be used for vapor treatment for the duration (approx. 1 year) that ERH was operated. Due to the 99.9% destruction effectiveness rate of FTO, the production of combustion by-products (e.g., dioxin) above background concentrations is unlikely. After the first year, ERH would be completed and it is estimated that the mass loading will be significantly reduced and switching to a GAC vapor treatment system would be more cost effective.

Site Characteristics

Area of Source control:	
'A' and 'B' Exposition groundwater zones:	69,400 ft^2 (within 1,000 ppb contour)
	10,700 ft^2 (within 10,000 ppb contour)
Analytical Data:	
Maximum concentration of Primary COCs in 'A' Zone:	TCE (27,000 µg/L), cis-1,2-DCE (2,600 µg/L) and VC (100 µg/L)
Maximum concentration of Primary COCs in 'B' Zone:	TCE (21,000 µg/L), cis-1,2-DCE (14,000 µg/L) and VC (780 µg/L)

<table>
<tr><th colspan="2">Alternative SG5a – Electrical Resistance Heating with Vapor Extraction/Vacuum-Enhanced Groundwater Extraction/Pump and Treat/ Monitored Natural Attenuation/Ultraviolet Oxidation/Flameless Thermal Oxidation and Granular Activated Carbon (cont'd)
Lower Vadose Soil and Exposition Groundwater Remediation Zone</th></tr>
<tr><th colspan="2">Site Characteristics</th></tr>
<tr><td>Hydrogeologic Data:</td><td></td></tr>
<tr><td>Depth to groundwater in Exposition Aquifer:</td><td>67 ft bgs</td></tr>
<tr><td>Saturated Soil Thickness:</td><td>50 ft</td></tr>
<tr><td>Direction of groundwater flow in 'A' Zone:</td><td>Southwest</td></tr>
<tr><td>Direction of groundwater flow in 'B' Zone:</td><td>West-southwest</td></tr>
<tr><td>Hydraulic conductivity (average for 'A' Zone):</td><td>1.46E-03 ft/min</td></tr>
<tr><td>Hydraulic conductivity (average for 'B' Zone):</td><td>3.27E-02 ft/min</td></tr>
<tr><td>HVDPE Pilot Test Data:</td><td>Vacuum ROI of 54 ft at 68 scfm and 14 in of Hg</td></tr>
<tr><td>Receptors:</td><td></td></tr>
<tr><td>Most shallow well used for domestic production:</td><td>Located approx. 4,000 ft southwest of site; screen interval begins at 350 feet bgs.</td></tr>
<tr><td>Closest well used for domestic production:</td><td>Located approx. 2,600 ft southwest of site; screen interval begins at 610 feet bgs.</td></tr>
<tr><td>Residential neighborhoods:</td><td>Located to the south and downgradient</td></tr>
<tr><th colspan="2">Conceptual Design Components and Assumptions</th></tr>
<tr><th>Component</th><th>Assumptions</th></tr>
<tr><td>Treatment Criteria: Same for pilot study and full-scale treatment via ERH. Air treatment criteria to be determined in accordance with South Coast Air Quality Management District discharge permit. Target discharge <25 ppmv at an average total destruction efficiency of 99%.

For water, target discharge <5 μg/L for max daily flow of 77,000 gpd of condensed water vapor (approximately 54 gpm).</td><td>• Soil vapor and groundwater treatment system influent and effluent to be sampled daily during startup period; weekly after documented stabilization or trend; quarterly or in accordance with discharge permit thereafter.
• Additional air monitoring via PID would be performed to supplement sampling data.</td></tr>
<tr><td>Pilot Test: Pilot test with six electrodes is recommended to confirm site characteristics (i.e. soil resistivity, electrode diameter, moisture requirements, and radius of influences (for heating and vapor extraction).

Surface recovery of soil vapor will be achieved using 3 soil vapor extraction wells screened from approx. 10-50 ft bgs, designed and operated at full scale using a 250-scfm blower.

Surface recovery of water (from moisture stripping) will amount to approximately 1,400 gpd. Treatment process using UV oxidation would provide the most effective contaminant removal/destruction.</td><td>• Pilot study area approx. 2,000 s.f. x 50 feet thick.
• Typical HSA drill rig used for drilling 6 electrode borings and three 2-inch VE wells
• Assumes one fenced compound for electrical equipment and separate compound for soil vapor and water treatment.
• ERH evaluation soil sampling assumes 3 borings to 100 ft bgs with 1 soil sample collected at each major lithosome (30 total samples for VOCs analysis).
• Pilot study evaluation reporting will make recommendation for suitability of ERH at the site.
• Duration of test and reporting: 6 months.</td></tr>
</table>

Alternative SG5a – Electrical Resistance Heating with Vapor Extraction/Vacuum-Enhanced Groundwater Extraction/Pump and Treat/ Monitored Natural Attenuation/Ultraviolet Oxidation/Flameless Thermal Oxidation and Granular Activated Carbon (cont'd) *Lower Vadose Soil and Exposition Groundwater Remediation Zone*	
Conceptual Design Components and Assumptions	
Component	**Assumptions**
Full Scale ERH within 10,000 ppb contour: Approximately ninety-six electrodes would be used to treat the source area to a depth of 100 ft bgs. Eight power delivery stations would be positioned at the surface around the perimeter of the 10,000 ppb contour. The surface within the 10,000 ppb plume contour would be fenced off and screened. Eighteen vapor extraction wells will be evenly spaced among the electrodes to extract the vaporized groundwater and contaminant load. Total blower requirement will be approximately 1,000 scfm (not including vacuum-enhanced groundwater extraction wells outside the 10,000 ppb contour).	• Array size, electrode diameter, and installation components are assumed to be the same as pilot scale. • Power supply equipment and connection organized by vendor. • Assume one 1,000-scfm blower with above ground placement of piping within the 10,000 ppb plume contour. • ERH evaluation soil sampling assumes 30 borings to 100 ft bgs with 1 soil sample collected at each major lithosome (300 total samples for VOCs analysis).
Vacuum-Enhanced and Groundwater Pumping Well Networks: Well network design is based on pump test data (average width of capture of 45 ft along downgradient axis; average width of capture of 69 ft along cross-gradient axis). <u>Between 10,000 and 1,000 ppb contours</u>: Twelve (12) vacuum-enhanced groundwater extraction wells will be installed between 10,000 and 1,000 ppb contours in two networks: 'A' Zone wells and 'B' Zone wells. System flow of 40 gpm (2.0 gpm x [20] 'A' and 'B' wells). Wells are typical P&T wells to which a vacuum is applied. <u>Between the 1,000 and 10 ppb contour:</u> Fifteen (15) P&T wells will be installed in three networks: wells screened in the 'A' Zone, wells screened in the 'B' Zone, and wells screened continuously through the 'A' and 'B' Zones. System flow of 44 gpm (2.0 gpm x [3] 'A' and [3] 'B' wells; 4.0 gpm x [9] 'A' and 'B' wells. To prevent the potential for cross contamination between the different Exposition Zones, the wells screened continuously through the 'A' and 'B' Zones are located outside the 100 ppb plume contour line. <u>Outside the 10 ppb contour</u> MNA would be used outside the 10 ppb composite plume to demonstrate plume reduction and/or point of compliance.	• Wells to be situated predominantly in the source area and along public right-of-ways. • All piping systems outside the 10,000 ppb plume contour shall be placed in a trench network. • Assume one 1,000-scfm blower. • Groundwater extraction rate is estimated to be 2 gpm for 'A' and 'B' Zones for a total flow of 84 gpm. • All wells shall be 6-inch diameter, Schedule 80 PVC. A 0.5 hp submersible pump will be installed in each well. • 'A' Zone: 9 wells, Schedule 80 PVC, screened 65 to 75 ft bgs. • 'B' Zone: 9 wells, Schedule 80 PVC, screened 80 to 100 ft bgs. • 'A' and 'B' Zone: 9 wells Schedule 80 PVC, screened 65 to 100 ft bgs. • 'C' Zone: 5 existing wells shall be used as needed. • Assumptions are based on HVDPE pilot test. (Refer to Appendix D for the results.)

Alternative SG5a – Electrical Resistance Heating with Vapor Extraction/Vacuum-Enhanced Groundwater Extraction/Pump and Treat/ Monitored Natural Attenuation/Ultraviolet Oxidation/Flameless Thermal Oxidation and Granular Activated Carbon (cont'd) *Lower Vadose Soil and Exposition Groundwater Remediation Zone*	
Conceptual Design Components and Assumptions	
Component	**Assumptions**
Groundwater Treatment System: UV oxidation was selected based on ability to meet treatment discharge requirements. A fenced and covered treatment compound would be mounted on a 20 ft by 30 ft concrete pad with containment foundation (to be shared with vapor treatment). Handling and storage of hydrogen peroxide requires special safety precautions. Electrical service and remote monitoring communication system would be tied into local services with possible back-up power generation. High turbidity, oil and grease, or metal ions would cause interference with UV treatment. It is assumed that typical pretreatment (filtration) for turbidity would be performed.	• Design flow and influent conc. are 100 gpm and 6.2 ppm total VOC • Treatment criterion is to be based on PSSRGs (Table 2.1). • Treatment system influent and effluent to be sampled daily during 7-day startup; quarterly after documented stabilization; semiannually after established trend or continued stabilization. Effluent sampling frequency would be determined by discharge permit. • Long-term O&M plan to be implemented for treatment system. • Influent trench and pipe = 1,200 ft Effluent trench and pipe = 500 ft
Soil Vapor Treatment System: The selected soil vapor treatment process, FTO for the first year followed by GAC for the remaining years, would be housed in the treatment compound alongside the groundwater treatment system. Treatment criteria will be determined in accordance with the South Coast Air Quality Management District (SCAQMD) discharge permit. Target destruction efficiency would average 99% with concentrations of combustion by-products (e.g., dioxin) below background concentrations during FTO operation and low (approved) concentrations of vinyl chloride and 1,4 dioxane emissions during GAC operation.	• Total design system flow of 2,000 scfm. • Estimated average first year influent vapor concentration of 315 ppm • Treatment system influent and effluent to be sampled daily during 7-day startup; weekly after documented stabilization or trend; quarterly or in accordance with discharge permit thereafter. • Additional monitoring via PID will be performed to supplement sampling data and to schedule timing for switching on-line wells. • Additional monitoring via PID will be performed to supplement sampling data and to schedule timing for switching on-line wells.
Monitoring Well Network: To be established to assess potential migration of contaminants and reduction in concentrations. Wells within each network (Exposition 'A' and 'B') will be situated to characterize conditions upgradient, downgradient, within plume, and lateral extent of plume.	• A' Zone: 10 wells, 2-inch diameter, Schedule 40 PVC, screened 65 to 75 ft bgs. • 'B' Zone: 10 wells, 2-inch diameter, Schedule 40 PVC, screened 80 to 100 ft bgs. • 'C' Zone: 5 existing wells shall be used as needed.
Monitoring/Reporting Frequency: Reporting will be performed in compliance with permits and to document contaminant removal rates, flows, cleanup forecasts, and groundwater gradient maps, in appropriate frequency to data collection.	• Semi-annual groundwater monitoring is recommended based on maximum average velocity of 0.5 ft/day. • Annual monitoring may be recommended after demonstration of treatment.

Alternative SG5a – Electrical Resistance Heating with Vapor Extraction/Vacuum-Enhanced Groundwater Extraction/Pump and Treat/ Monitored Natural Attenuation/Ultraviolet Oxidation/Flameless Thermal Oxidation and Granular Activated Carbon (cont'd) *Lower Vadose Soil and Exposition Groundwater Remediation Zone*	
Conceptual Design Components and Assumptions	
Component	**Assumptions**
Estimated Project Duration: ERH will require approximately 1 year for treatment of the >10,000 ppb plume contour source area. Vacuum-enhanced groundwater extraction and P&T is expected to continue for approximately 4 additional years. Groundwater monitoring is required for an additional 5 years for a total of 10 years.	• Approximately 10 years.
Conceptual Design Considerations	
Additional requirement of park area (approximately 12,000 ft^2) for power system delivery layout.	

3.4.3.7 Alternative SG5b – Electrical Resistance Heating with Vapor Extraction/Vacuum-Enhanced Groundwater Extraction/Pump and Treat Monitored Natural Attenuation/Ultraviolet Oxidation/Granular Activated Carbon

Alternative SG5b – Electrical Resistance Heating with Vapor Extraction/ Vacuum-Enhanced Groundwater Extraction/Pump and Treat/ Monitored Natural Attenuation/Ultraviolet Oxidation/Granular Activated Carbon *Lower Vadose Soil and Exposition Groundwater Remediation Zone*	
Description	
The treatment process and conceptual design is the same as described in Alternative SG5a with the exception of vapor treatment, which would employ only GAC. GAC absorbs COCs from the extracted vapor for later disposal at an off-site approved facility. GAC is not an effective method of treatment for low molecular weight VOCs, such as vinyl chloride, or COCs with low adsorptive capacity, such as 1,4-dioxane. Further evaluation of the proportion of low molecular weight VOCs in the vapor stream would be necessary prior to implementing GAC vapor treatment. Assuming cleanup criteria are met, the treated soil vapor would discharge to the air above the site.	
Site Characteristics	
The Site Characteristics are the same as Alternative SG5a	
Conceptual Design Components and Assumptions	
Component	**Assumptions**
Treatment Criteria: See Alternative SG4a for the Treatment Criteria.	Same as Alternative SG5a.
Pilot Test: See Alternative SG4a for the Pilot Test design.	Same as Alternative SG5a.
Full Scale ERH within 10,000 ppb contour: See Alternative SG5a for the ERH conceptual design.	Same as Alternative SG5a.
Vacuum-Enhanced and Groundwater Pumping Well Networks: See Alternative SG5a for the vacuum-enhanced and groundwater pumping well conceptual design.	Same as Alternative SG5a.
Groundwater Treatment System: See Alternative SG5a for the groundwater treatment system conceptual design.	Same as Alternative SG5a.
Soil Vapor Treatment System: The selected soil vapor treatment process, GAC, would be housed in the treatment compound alongside the groundwater treatment system. Treatment criteria will be determined in accordance with the South Coast Air Quality Management District (SCAQMD) discharge permit. Target destruction efficiency would average 99% with low (approved) concentrations of vinyl chloride and 1,4 dioxane emissions during GAC operation.	Same as Alternative SG5a without FTO.
Monitoring Well Network: See Alternative SG5a for the monitoring well network conceptual design.	Same as Alternative SG5a.
Monitoring/Reporting Frequency: See Alternative SG5a for the monitoring/reporting conceptual design.	Same as Alternative SG5a.
Estimated Project Duration: Same as Alternative SG5a.	Approximately 10 years.
Conceptual Design Considerations	
Additional requirement of park area (approximately 12,000 ft^2) for power system delivery layout.	

4.0 DETAILED EVALUATION OF ALTERNATIVES

The detailed evaluation of the retained remedial alternatives presents a comparison of relevant information needed to allow decision makers to select a site remedy(s). As part of the National Contingency Plan (40 CFR 300.430 (e)(9)), each alternative is assessed against the nine evaluation criteria. The U.S. EPA developed the nine criteria to address CERCLA statutory considerations for remedial actions that must be addressed in the Record of Decision (ROD) as well as technical and policy considerations that have proven to be important for selecting remedial alternatives.

The first two criteria are threshold criteria that must be met by each alternative. The next five criteria are the primary balancing criteria upon which the evaluation is mostly based. The final two criteria are referred to as modifying criteria and are applied, following the public comment period, to evaluate state and community acceptance. The evaluation of alternatives reflects the scope and complexity of site problems and alternatives being evaluated and considers the relative significance of the factors within each criterion. The nine evaluation criteria are as follows:

Threshold Criteria
1. Overall protection of human health and the environment
2. Compliance with ARARs (applicable or relevant and appropriate standards)

Primary Balancing Criteria
3. Long-term effectiveness and permanence
4. Reduction of toxicity, mobility or volume
5. Short-term effectiveness
6. Implementability
7. Cost

Modifying Criteria
8. State acceptance
9. Community acceptance

It is assumed that each of the CERCLA criteria are equally important. This may not always be representative, however, because certain criteria can have more importance, depending on site-specific circumstances. For example, threshold factors must be achieved and therefore might be seen as more important than a balancing factor, such as implementability, that might be of less importance. The detailed evaluation for each remedial alternative of the three remediation zones is performed in the following sections.

4.1 Detailed Evaluation of Alternatives for Surface and Near-Surface Soil Remediation Zone

The three remedial alternatives best suited for the surface and near-surface soil (0 to 3 ft bgs) remediation zone, as described in Section 3.4.1, include:

- N1 - No Action
- N2 - Soil Cover/Revegetation
- N3 – Excavation and Offsite Disposal

These three alternatives were evaluated in detail using the nine evaluation criteria described above. Note that additional evaluation of two of the criteria, state acceptance and community acceptance, will be performed following the public comment period. The detailed evaluations are presented in Table 4.0. Detailed cost estimates for each alternative within this remediation zone are presented in Appendix G and are summarized in Table 4.0.

4.2 Detailed Evaluation of Alternatives for Upper Vadose Soil and Perched Groundwater Remediation Zone

The six remedial alternatives best suited for the upper vadose soil and perched groundwater (3 to 35 ft bgs) remediation zone, as described in Section 3.4.2, include:

- SP1 - No Action
- SP2a – High-Vacuum Dual-Phase Extraction/UV Oxidation/Flameless Thermal Oxidation
- SP2b – High-Vacuum Dual-Phase Extraction/UV Oxidation/Granular Activated Carbon
- SP3 – *In-situ* Chemical Oxidation
- SP4 – Enhanced *In-situ* Bioremediation
- SP5 – Monitored Natural Attenuation

These six alternatives were evaluated in detail using the nine evaluation criteria described above. Note that additional evaluation of two of the criteria, state acceptance and community acceptance, will be performed following the public comment period. The detailed evaluations are presented in Table 4.1. Detailed cost estimates for each alternative are presented in Appendix H and are summarized in Table 4.1.

4.3 Detailed Evaluation of Alternatives for Lower Vadose Soil and Exposition Groundwater Remediation Zone

The seven remedial alternatives best suited for the lower vadose soil and the Exposition groundwater (35 to 100 ft bgs) remediation zone, as described in Section 3.4.3, include:

- SG1 - No Action
- SG2 – *In-situ* Chemical Oxidation/*In-situ* Chemical Reduction/Pump and Treat/Monitored Natural Attenuation/Ultraviolet Oxidation
- SG3 – Enhanced *In-situ* Bioremediation/Pump and Treat/Monitored Natural Attenuation/Ultraviolet Oxidation
- SG4a – Vacuum-Enhanced Groundwater Extraction/Pump and Treat/ Monitored Natural Attenuation/Ultraviolet Oxidation/Flameless Thermal Oxidation/Granular Activated Carbon
- SG4b – Vacuum-Enhanced Groundwater Extraction/Pump and Treat/ Monitored Natural Attenuation/Ultraviolet Oxidation/Granular Activated Carbon

- SG5a – Electrical Resistance Heating with Vapor Extraction/Vacuum-Enhanced Groundwater Extraction/Pump and Treat/ Monitored Natural Attenuation/Ultraviolet Oxidation/Flameless Thermal Oxidation/Granular Activated Carbon
- SG5a – Electrical Resistance Heating with Vapor Extraction/Vacuum-Enhanced Groundwater Extraction/Pump and Treat/Monitored Natural Attenuation/Ultraviolet Oxidation/Granular Activated Carbon

These seven alternatives were evaluated in detail using the nine evaluation criteria described above. Note that additional evaluation of two of the criteria, state acceptance and community acceptance, will be performed following the public comment period. The detailed evaluations are presented in Table 4.2. Detailed cost estimates for each alternative are presented in Appendix I and are summarized in Table 4.2.

4.4 Comparative Analysis of Alternatives

The comparative analysis considers the trade-offs between the benefits, impacts, and costs associated with each remedial alternative. The final selection of preferred alternatives in the record of decision (ROD) will be based on the comparative analysis, or the relative advantages and disadvantages of each alternative.

The following sections compare each set of alternatives (three alternatives for the Surface and Near-Surface Soil Remediation Zone, six alternatives for the Upper Vadose Soil and Perched Groundwater Remediation Zone, and seven alternatives for the Lower Vadose Soil and Exposition Groundwater Remediation Zone) relative to the nine CERCLA evaluation criteria. The No Action alternative is not discussed in detail in the comparative analysis since it did not meet the two threshold criteria, overall protection of human health and the environment and compliance with ARARs/TBCs, and RAOs would not be met.

4.4.1 Comparative Analysis of Surface and Near-Surface Soil Remediation Zone Alternatives

The comparative analysis of remediation alternatives for the Surface and Near-Surface Soil Remediation Zone is provided below, organized by evaluation criterion.

4.4.1.1 Overall Protection of Human Health and the Environment

All of the Surface and Near-Surface Soil Remediation Zone alternatives, except for Alternative N1 (No Action), would reduce current baseline risks and would provide some level of protection to human health and the environment.

Alternative N3 (Excavation and Offsite Disposal) would provide the highest degree of protection to human health and the environment from COCs in surface and near-surface soils because COCs would be physically removed from the site and disposed in a secure landfill with long-term maintenance. This alternative would eliminate potential pathways to human and ecological exposure at the Site and the potential for migration of COCs to groundwater through percolation.

Although Alternative N2 (Soil Cover/Revegetation) would not physically remove COCs, the 1-foot soil cover would reduce the likelihood of direct contact with these soils. Because this is the primary route of human and ecological exposure to COCs, this alternative would be protective of human health and the environment. Migration of COCs to groundwater as a result of percolation is considered a minor concern since the COCs (PAHs, metals) are characteristically non-mobile as demonstrated by the duration they have remained in place at the Site. Additionally, the percolation of water through these soils would create favorable conditions for natural bioattenuation of the organic COCs over time. Through maintenance of a vegetative cover and quarterly inspections for erosion, this alternative would prevent future exposure. The addition of a non-woven geotextile layer below the soil cover would enhance this option by acting as an indicator of excessive erosion and providing an additional cover layer to ensure the effectiveness of the soil cover.

4.4.1.2 Compliance with the ARARs/TBCs

The evaluation of the ability of alternatives to comply with ARARs/TBCs included a review of chemical-specific and action-specific ARARs/TBCs that was presented in Section 2.0 of this report. There are no known location-specific ARARs/TBCs for this site.

Alternative N3 (Excavation and Offsite Disposal) would meet ARARs/TBCs through physical removal of surface and near surface soils from the Site and transportation of the affected soils to a certified landfill. Alternative N2 (Soil Cover/Revegetation) would likely meet ARARs/TBCs through the elimination of potential exposure pathways. Alternative N1 (No Action) would not meet ARARs/TBCs within a reasonable timeframe.

4.4.1.3 Long-Term Effectiveness and Permanence

Alternative N3 (Excavation and Offsite Disposal) would afford the highest degree of long-term effectiveness and permanence because surface and near surface soils would be physically removed from the site. The soil would be placed in a secured and managed landfill facility with long-term controls in effect. This would effectively eliminate risks related to direct contact in this remediation zone.

Alternative N2 (Soil Cover/Revegetation) is considered adequate and reliable in eliminating exposure risks and preventing migration of COCs (via erosion). This alternative would require indefinite surface inspections and implementation of corrective actions (e.g., maintenance and/or repair of their surfaces in order to address erosion and surface wear) to remain effective.

4.4.1.4 Reduction of Toxicity, Mobility, and Volume (TMV) through Treatment

By physically transferring all contaminated soil offsite to a secure landfill, Alternative N3 (Excavation and Offsite Disposal) would reduce the TMV of surface and near-surface soils at the Site, but the toxicity and volume of the contaminated soils would remain until treated. Secure lined landfills with leachate collection systems, by design, reduce mobility. RCRA hazardous materials are subject to pre-placement treatment to meet land disposal restrictions, which, if required, would reduce toxicity.

Although Alternative N2 (Soil Cover/Revegetation) would not reduce the toxicity or volume of COCs within this remediation zone, this alternative would provide significant reductions in contaminant mobility at the Site. The lack of reduction in toxicity and volume would be compensated for by the elimination of potential exposure routes.

4.4.1.5 Short-Term Effectiveness

This evaluation criterion is two-fold. One aspect addresses the time until remedial action objectives are met and the other addresses the effects of the alternative during the construction and implementation phase of the alternative.

Alternative N2 (Soil Cover/Revegetation) is anticipated to have the greatest short-term effectiveness for quickly achieving RAOs (1 – 2 months for construction of soil cover and 2 – 4 months for construction of cap) with minimal impact to remedial construction workers, the community, and the environment. Potential short-term risks consist of dust emissions, which could be mitigated through engineering controls (dust suppression), air monitoring, and PPE.

Alternative N3 (Excavation and Offsite Disposal) offers less short-term effectiveness than Alternative N2, because it would require the excavation, handling, and mixing of contaminated soil. Excavation and soil movement operations have the potential to generate significant amounts of dust that could be a threat to construction workers, the community, and the environment. In addition, the increase in traffic associated with hauling contaminated soil offsite and importing clean fill would significantly impact the surrounding communities. Traffic concerns could be lessened during the project through traffic routing (e.g., keeping all traffic to and from the Site restricted to Slauson Blvd. would eliminate neighborhood truck traffic). The dust and noise pollution could be mitigated with proper planning and suitable health and safety measures, such as engineering controls (dust suppression), air monitoring, and PPE, but not to the degree typical of a soil cover alternative.

4.4.1.6 Implementability

Alternative N2 (Soil Cover/Revegetation) would be the simplest alternative to implement from an administrative and technical viewpoint. Alternative N2 would require administrative efforts to modify land deeds in order to prevent future development of the property and to allow for indefinite monitoring and maintenance programs. Engineering services and materials would be readily available for constructing a soil cover.

Alternative N3 (Excavation and Offsite Disposal) would require significant administrative efforts for the profiling, manifesting, and disposing of contaminated soil. In addition, this alternative presents potential future liability associated with hauling COCs offsite. Technically, however, the operation would be simple to implement through use of the following planning measures: dust control, the staging of trucks, scheduling of traffic flow, and the weighing of vehicles. Several health and safety risks would need to be addressed as well with regard to truck traffic and the general hazards associated with excavation activities. The construction services and materials would be readily available for excavation and offsite disposal.

4.4.1.7 Estimated Cost

A summary of the estimated costs for each of the Surface and Near-Surface Soil Remediation Zone remedial alternatives is presented in Table 4.0. A more detailed cost estimate for each alternative is provided in Appendix G.

The cost estimates presented in Table 4.0 and in Appendix G have been developed strictly for comparing the alternatives. The final costs of the treatment alternatives will depend on competitive bids, actual market conditions, actual site conditions, final project scope, and implementation schedules. Because of these factors and those unforeseen, project feasibility and requirements must be reviewed carefully to adequately address the decisions related to project funding.

The cost estimates are "order-of-magnitude" estimates having an intended accuracy range of +50% to –30%. They are not intended to limit the flexibility in the selection of the remedial design but to provide a basis for evaluating cost in light of the other modifying criteria. The specific details of the remedial actions and cost estimates would be refined once all screening criteria are considered in preparation of the ROD.

With exception to Alternative N1 (No Action), Alternative N2 (Soil Cover/Revegetation) is the least expensive alternative for remediation of surface and near-surface soils and presents the best value with a total present worth of approximately $773,000. Alternative N3 (Excavation and Offsite Disposal) is the most expensive option (approximately $1.3 million) as there are significantly more administrative and technical considerations. In addition, a major cost uncertainty associated with Alternative N3 is the actual transportation and disposal costs, which vary seasonally.

Also for consideration is the relatively high O&M costs (for 30 years of surface maintenance) associated with Alternative N2 (Soil Cover/Revegetation). In the event that O&M costs are reduced as a result of a shared budget with the Maywood Riverfront Park project, the actual project costs would be closer to the capital costs (approximately $358,000). As an additional consideration, the capital costs of Alternative N2 are approximately one-quarter of the capital costs of Alternative N3 (approximately $1.3 million).

4.4.1.8 State Acceptance

Final acceptance by the state can only occur following the state review of this document.

4.4.1.9 Community Acceptance

A public meeting will be held after the Final FS is published to present and receive public input on the proposed remedial alternatives for the Pemaco Site.

4.4.2 Comparative Analysis of Upper Vadose Soil and Perched Groundwater Remediation Zone Alternatives

The comparative analysis of remediation alternatives for the Upper Vadose Soil and Perched Groundwater Remediation Zone is presented below, organized by screening criterion.

4.4.2.1 Overall Protection of Human Health and the Environment

All of the alternatives, except for Alternative SP1 (No Action), would reduce current baseline risks and would provide some level of protection to human health and the environment.

Alternatives SP2a (HVDPE/UV Ox/FTO/GAC) and SP2b (HVDPE/UV Ox/GAC) would likely reduce COCs to remediation goals within both the soil column and the perched groundwater zone, thereby providing the highest levels of protection to human health and the environment. The removal of COCs in both media would eliminate pathways of human exposure and the potential for migration of COCs to deeper groundwater zones. Alternative SP2b (HVDPE/UV Ox/GAC) would require evaluation of the vapor stream, especially with respect to low molecular weight VOCs (vinyl chloride) and COCs with a low adsorptive capacity (1,4-dioxane), to indicate whether GAC vapor treatment would provide adequate protection of human health and the environment.

Alternatives SP3 (*In-Situ* Chemical Oxidation) and SP4 (Enhanced *In-Situ* Bioremediation) would provide adequate protection of human health and the environment through reduction of COCs in the perched groundwater zone; however, these alternatives do not address upper vadose soils and the risks associated with vapor phase migration of COCs to the surface. In addition, these alternatives would not be as protective as Alternatives SP2a and SP2b (HVDPE alternatives) in terms of COC reduction in perched groundwater because of the presence of "hot spots" or isolated pockets of elevated concentrations of COCs (>1,000 ppb) that may not be mitigated through *in-situ* treatment processes. The reduction of COCs in groundwater to remedial goals would depend not only on uniform oxidant and/or substrate delivery throughout the entire area of the perched groundwater plume, but also on large volumes of oxidant/substrate material being delivered to isolated contamination pockets. Where the process would be effective, COC concentrations would be reduced to achieve remediation goals. Where the process is not effective, COCs would continue to pose a risk to potential receptors. Impacted upper vadose soils, which would not be addressed under Alternatives SP3 and SP4, may act as a continual source of contamination to the perched groundwater and deeper saturated zones through leaching as well as provide a potential pathway for VOC migration to the surface.

Alternative SP5 (Monitored Natural Attenuation) may reduce contamination in both media within this remediation zone through attenuation and degradation processes. As such, MNA would likely be protective of human health and the environment in some capacity, but not within a reasonable timeframe.

4.4.2.2 Compliance with the ARARs/TBCs

The screening of the ability of alternatives to comply with ARARs/TBCs included a review of chemical-specific and action-specific ARARs/TBCs that was presented in Section 2.0 of this report. There are no known location-specific ARARs/TBCs for this site.

Alternatives SP2a (HVDPE/UV Ox/FTO/GAC) and SP2b (HVDPE/UV Ox/GAC) would meet ARARs/TBCs for both *in-situ* soil and groundwater as well as for extracted groundwater (through *ex-situ* groundwater treatment via UV Ox). However, only Alternative SP2a (HVDPE/UV Ox/FTO/GAC) would meet ARARs/TBCs for extracted vapor (in terms of discharge criteria) since a FTO system would be used during the first year of HVDPE system operation. It is estimated that the largest amount of contamination, estimated to be 50 to 60% of the total mass, will be extracted during the first year. The COCs, such as 1,4-dioxane and vinyl chloride, which are prevalent in the perched zone, cannot be treated efficiently by GAC at high concentrations. It is estimated that the concentrations of these two contaminants will be significantly reduced after the first year, to the extent that GAC may be effectively used.

It is unlikely that the FTO vapor treatment system associated with Alternative SP2a (HVDPE/UV Ox/FTO/GAC) will emit products of incomplete combustion, such as dioxins or furans, above background levels due to the system's high destruction efficiency. The FTO would be regularly monitored to document compliance with emissions standards.

Alternatives SP3 (*In-Situ* Chemical Oxidation) and SP4 (Enhanced *In-Situ* Bioremediation) would *not* achieve soil TBCs, but perched groundwater ARARs would likely be met.

Alternatives SP5 (Monitored Natural Attenuation) and SP1 (No Action) would not achieve ARARs and TBCs within a reasonable timeframe.

4.4.2.3 Long-Term Effectiveness and Permanence

Alternatives SP2a (HVDPE/UV Ox/FTO/GAC) and SP2b (HVDPE/UV Ox/GAC) would likely provide the highest degree of long-term effectiveness and permanence because these alternatives use treatment technologies that would reduce COC concentrations within perched groundwater and upper vadose soils to remediation goals. UV Oxidation and FTO would effectively destroy COCs in extracted groundwater and vapor onsite; whereas permanent destruction of COCs in vapor adsorbed to GAC would take place at an offsite facility. Removal of contaminants within perched groundwater and upper vadose soils at the Site would be permanent with no treatment residuals and no untreated residual risks. HVDPE consists of generally conventional and well-proven technologies and is expected to be highly reliable when adequately operated and maintained. Both alternatives would require monitoring of the remediation area to assure effectiveness over the duration of system operation.

Unlike Alternatives SP2a and SP2b, Alternatives SP3 (*In-Situ* Chemical Oxidation) and SP4 (Enhanced *In-Situ* Bioremediation) would not physically remove COCs; rather, they would be destroyed or degraded *in-situ*. Alternatives SP3 and SP4 would address baseline risks associated with the perched groundwater plumes. Assuming the appropriate dispersion, distribution, and homogeneity of the treatment process, Alternatives SP3 and SP4 would reduce the majority of COCs in the perched groundwater zone over the entire plume area. Where the processes are effective, remediation goals for the perched groundwater would be achieved.

Alternatives SP3 and SP4 would be ineffective treating COCs in upper vadose soils since dispersion mechanisms for oxidants/substrates are uncertain in unsaturated conditions. Similarly, the treatment of impermeable soils in both unsaturated and saturated conditions is difficult and could result in untreated residual contamination, leading to a rebound of COCs after treatment. The effectiveness of these alternatives in unsaturated and/or impermeable conditions would be a function of the density of oxidant/substrate distribution points. Therefore, design of the treatment application may be tailored to *partially* mediate the ineffectiveness of Alternatives SP3 and SP4 in unsaturated and/or impermeable conditions.

There is an additional uncertainty associated with the dechlorination reaction predicted for the SP4 (Enhanced *In-Situ* Bioremediation) Alternative. There are some instances where PCE and TCE may not complete the biologically mediated reductive dechlorination pathway to ethene (assumes application of HRC), resulting in the possible generation and accumulation of vinyl chloride, which is more toxic and more mobile than TCE and PCE. Several treatments (i.e., substrate injections) and long-term management and monitoring would be required to eliminate any remaining source of risk. Also, some of the COCs at

Pemaco are organic compounds that will only biodegrade anaerobically (e.g., the chlorinated ethenes), some that only degrade aerobically (e.g., petroleum hydrocarbons), and some that are more or less recalcitrant to biodegradation (e.g., 1,4-dioxane). Any Enhanced *In-Situ* Bioremediation program designed for the site would need to address this and would likely be implemented in several phases.

Although long-term effectiveness and permanence of Alternatives SP2a, SP2b, SP3, and SP4 may be documented through MNA, Alternative SP5 (MNA) alone would require approximately 50+ years to achieve remediation goals within this remediation zone.

4.4.2.4 Reduction of Toxicity, Mobility, and Volume (TMV) through Treatment

Alternatives SP2a (HVDPE/UV Ox/FTO/GAC) and SP2b (HVDPE/UV Ox/GAC) use technologies that increase the rate of mass transfer and enhance the physical removal of COCs in both perched groundwater and upper vadose zone soils, effectively reducing the TMV of COCs within both media. The major difference in these alternatives with respect to TMV lies in the *ex-situ* vapor treatment process options (i.e., FTO and GAC versus GAC alone). FTO would permanently destroy COCs onsite, eliminating the TMV of vapor contaminants extracted from the subsurface, whereas GAC would only reduce the mobility and volume of COCs onsite. All used carbon would likely undergo treatment at the approved disposal facility where toxicity would be reduced.

Alternatives SP3 (*In-Situ* Chemical Oxidation) and SP4 (Enhanced *In-Situ* Bioremediation) would not physically remove COCs from the subsurface like HVDPE, nor would they address upper vadose soils. But, through the introduction and uniform distribution of oxidants and substrates, these alternatives would reduce the toxicity and volume of COCs in perched groundwater. These alternatives would not affect the mobility of COCs but would transform the COCs into less toxic compounds with the exceptions noted below. Alternative SP3 (*In-Situ* Chemical Oxidation) uses an aggressive technology that is typically faster and more predictable than Alternative SP4 (Enhanced *In-Situ* Bioremediation), which relies on natural processes. While Alternative SP4 enhances these biological processes, they still work at relatively slow, unsustainable rates. Alternative SP4 could also result in the proliferation of PCE and TCE daughter products through incomplete dechlorination. One daughter product, vinyl chloride, is more toxic and more mobile than PCE and TCE. These treatment residuals would pose uncertain risks. In addition, the enhancement of anaerobic biodegradation of chlorinated ethenes is not effective for treating compounds that biodegrade under aerobic conditions (i.e., benzene, toluene).

Both Alternatives SP3 (*In-Situ* Chemical Oxidation) and SP4 (Enhanced *In-Situ* Bioremediation) have inherent physical limitations of oxidant/substrate delivery in the heterogeneous subsurface, which would likely result in post-treatment residual contamination in isolated, less permeable areas. Nonetheless, both alternatives would be effective in reducing the toxicity and volume of contamination in perched groundwater. Because of its aggressive nature, Alternative SP3 (*In-Situ* Chemical Oxidation) would be especially effective in the known pockets of elevated contamination (>1,000 ppb) given a dense distribution of substrate delivery points in those areas.

Alternative SP5 (MNA) may result in reduced TMV in both perched groundwater and upper vadose zone soils through natural attenuation and degradation processes, but not within a reasonable timeframe.

4.4.2.5 Short-Term Effectiveness

This screening criterion is two-fold. One aspect addresses the time until remedial action objectives are met; the other addresses the effects of the alternative during the construction and implementation phase of the alternative.

Alternatives SP2a (HVDPE/UV Ox/FTO/GAC) and SP2b (HVDPE/UV Ox/GAC) are anticipated to have the greatest short-term effectiveness with respect to meeting remedial action objectives. RAOs for both upper vadose soil and perched groundwater would likely be met within 5 years under Alternatives SP2a and SP2b. These alternatives are the only remedial options for this remediation zone that address both media within such a favorable timeframe.

Both Alternatives SP2a and SP2b, however, present potential risks to workers, the community, and the environment during construction and implementation (approximately 2 months for both alternatives). Alternatives SP2a and SP2b would involve installation of 32 extraction wells and construction of two aboveground treatment systems (groundwater and soil vapor). Alternative SP2a would involve the replacement of the FTO vapor treatment system with a GAC vapor treatment system after approximately 1 year of HVDPE operation. Risks associated with construction and implementation activities of these alternatives include: increased traffic and particulate emissions from vehicles. These risks can be mitigated with proper planning and suitable health and safety measures, such as traffic control, worker PPE, air monitoring, and restricted access to the aboveground treatment systems.

Alternatives SP3 (*In-Situ* Chemical Oxidation) and SP4 (Enhanced *In-Situ* Bioremediation) are similar with respect to short-term effectiveness, although Alternative SP3 is expected to reach perched groundwater RAOs at a faster rate than Alternative SP4 (ISCO) because *In-situ* Chemical Oxidation is more aggressive than Enhanced *In-situ* Bioremediation. Because Alternatives SP3 and SP4 rely on *in-situ* destruction and/or degradation remedial processes and have inherent uncertainties, these alternatives are expected to take longer to reach perched groundwater RAOs than Alternatives SP2a and SP2b (HVDPE alternatives), which involve physical removal of contaminants. Based on monitoring data and dependent on the effectiveness of the processes, it is anticipated that Alternatives SP3 and SP4 would take about 1 to 6 years to reach perched groundwater RAOs. Baseline risks to the community associated with contaminants in upper vadose soils would remain.

Both Alternatives SP3 (*In-Situ* Chemical Oxidation) and SP4 (Enhanced *In-Situ* Bioremediation) would involve the installation of 8 monitoring wells and the coring of injection points (approximately 100 for Alternative SP3 and 200 for Alternative SP4). Alternative SP3 (ISCO) would involve three injection events to be implemented in an approximate 6- to 9-month period; Alternative SP4 (EISB) would likely involve two applications over a 6-month period. Because of the *in-situ* nature of the alternatives, no *ex-situ* engineering controls or treatment systems would be required. The only short-term community risks associated with these alternatives consists of occasional increased traffic related to drilling activities. Additional risks to workers, beyond those linked directly to drilling, consist of the use of strong oxidants associated with Alternative SP3. Workers can mitigate these risks with proper planning and suitable health and safety measures, such as traffic control, appropriate PPE, and special handling of oxidants.

Alternative SP5 (MNA) is projected to take approximately 2 months to implement/construct (monitoring well installation) and 50+ years of operations to achieve perched groundwater

RAOs. Baseline risks to the community associated with contaminants in upper vadose soils would remain. Short-term physical risks associated with Alternative SP5 would arise from the installation of 8 monitoring wells. Short-term risks to the community and environment associated with drilling activities include increased traffic, particulate emissions, and potential worker exposure to upper vadose soils. These risks could be mitigated with proper planning and suitable health and safety measures, such as traffic control, dust suppression, air monitoring, and worker PPE.

4.4.2.6 Implementability

Alternative SP5 (MNA) would be the simplest alternative to implement and consists of a generally conventional, well proven, and implementable technology. Personnel, equipment, and materials are also readily available for implementation/operation.

Alternatives SP3 (*In-Situ* Chemical Oxidation) and SP4 (Enhanced *In-Situ* Bioremediation) are considered similar with respect to implementability and would be the next easiest to implement after SP5. Both alternatives would require injection well permits from appropriate state and local agencies prior to implementation. Pilot tests, as described in Sections 3.4.2.4 and 3.4.2.5, would be needed to establish suitability of the methods and to obtain additional design information. The addition of injection points and/or injection events to the assembled alternatives (approximately 100 injection points and 3 injection events for Alternative SP3 and 200 injection points and two applications for Alternative SP4) could be warranted based on system performance and actual monitoring data. In addition, based on the performance of initial applications, the distribution of oxidants and substrates for isolated pockets of elevated contamination would need to be evaluated. Both alternatives would require coordination with the City of Maywood park construction since injection wellheads would be situated within the park boundary. Initial disruption periods are estimated to be 6 months for either alternative. Personnel, equipment, and materials are generally available for implementation/operation for both alternatives. All of these considerations are considered easier to implement than Alternatives SP2a and SP2b (HVDPE alternatives) because no *ex-situ* treatment systems and piping networks are required.

Alternatives SP2a (HVDPE/UV Ox/FTO/GAC) and SP2b (HVDPE/UV Ox/GAC) are considered similar with respect to implementability and would be the least easy to implement. Alternative SP2b would have more operational requirements than Alternative SP2a during the first year of operation due to the close monitoring and frequent carbon replacement that would be required to ensure discharge criteria. On the other hand, Alternative SP2a would require the substitution of the FTO vapor treatment system with a GAC vapor treatment system once mass loading and the COCs, 1,4-dioxane and vinyl chloride, are significantly reduced. Both alternatives consist of generally conventional, well proven, and implementable technologies and are expected to be highly reliable when adequately operated and maintained. Personnel, equipment, and materials are readily available for implementation/operation. Coordination with the City of Maywood would be required for well installation activities (32 extraction wells and 8 monitoring wells), which would ideally be installed after final grading activities, but prior to landscaping, of the Maywood Riverfront Park. Well installation would take approximately 2 months. Modifications to the assembled alternative (e.g., additional extraction wells) over time could be expected and warranted based on system performance and monitoring data, which would be necessary as an indicator of HVDPE effectiveness and contaminant plume status. Discharge permits or disposal facility acceptance for treated groundwater would be required.

4.4.2.7 Estimated Cost

A summary of the estimated costs for each of the Upper Vadose Soil and Perched Groundwater Remediation Zone remedial alternatives is presented in Table 4.1. A more detailed cost estimate for each alternative is provided in Appendix H. The cost estimates presented in Table 4.1 and in Appendix H have been developed strictly for comparing the alternatives. The final costs of the treatment alternatives will depend on competitive bids, actual market conditions, actual site conditions, final project scope, and implementation schedules. Because of these factors and those unforeseen, project feasibility and requirements must be reviewed carefully to adequately address the decisions related to project funding.

The cost estimates are "order-of-magnitude" estimates having an intended accuracy range of +50% to –30%. They are not intended to limit the flexibility in the selection of the remedial design but to provide a basis for evaluating cost in light of the other modifying criteria. The specific details of the remedial actions and cost estimates would be refined once all screening criteria are considered in preparation of the ROD.

Alternative SP4 (Enhanced *In-situ* Bioremediation) has the lowest total present worth cost at approximately $1.7 million. The uncertainty in the final cost of this alternative lies in the ability of the injected substrate to effect contaminants trapped in the impermeable clay layers. Additional treatments or increasing the density of treatment points would increase the costs proportionately but are still estimated to provide the lowest total present worth cost, with the exception of Alternative SP1 (No Action).

Alternative SP5 (MNA) has the second lowest total present worth cost at approximately $2.4 million. Alternative SP5 is relatively expensive considering that no proactive treatment of contaminants would take place. Since Alternative SP5 would take a long time (approximately 50 years) to achieve RAOs, it is not considered cost effective. In addition, under Alternative SP5, contaminants in the perched zone could continue migrating to the Exposition groundwater zones, thereby increasing the cost to cleanup the deeper zone.

Alternative SP3 (*In-situ* Chemical Oxidation) has the third lowest total present worth cost at approximately $2.5 million. Like the EISB alternative, the uncertainty in the final cost of this alternative lies in the ability of the injected substrate to effect contaminants trapped in the impermeable clay layers. Additional treatments or increasing the density of treatment points would increase the costs proportionately.

Alternatives SP2a (HVDPE/UV Ox/FTO/GAC) and SP2b (HVDPE/UV Ox/GAC) have the highest total present worth costs at approximately $3.7 million and $3.6 million, respectively. Alternatives SP2a and SP2b utilize the best suited technologies for this remediation zone because it works well in both saturated and unsaturated conditions, unlike Alternatives SP3 and SP4, which rely on saturated conditions to facilitate treatment. Both of these alternatives have the highest degree of reliability as evidenced by their long history of use for similar applications and are therefore considered cost effective, relative to other alternatives. The only limitation of HVDPE, similar to Alternatives SP3 and SP4, is its ability to affect contaminants trapped in the impermeable clay layers in a predictable timeframe.

4.4.2.8 State Acceptance

To be addressed in the ROD.

4.4.2.9 Community Acceptance

To be addressed in the ROD.

4.4.3 Comparative Analysis of Lower Vadose Soil and Exposition Groundwater Remediation Zone Alternatives

The comparative analysis for the Lower Vadose Soil and Exposition Groundwater Remediation Zone alternatives is presented below, organized by evaluation criterion.

4.4.3.1 Overall Protection of Human Health and the Environment

All of the alternatives, except for Alternative SG1 (No Action), would reduce current baseline risks and would provide some level of protection to human health and the environment.

Alternatives SG5a (ERH with VE/Vacuum-Enhanced Groundwater Extraction/P&T/FTO/GAC) and SG5b (ERH with VE/Vacuum-Enhanced Groundwater Extraction/P&T/GAC) would reduce COCs to achieve remediation goals within both the lower vadose soil column and the Exposition groundwater zones, thereby providing the highest level of protection to human health and the environment. The physical removal of COCs would effectively eliminate all exposure pathways and the potential for migration of COCs to local production wells or regional Aquifer systems. Alternatives SG5a and SG5b are the only alternatives assembled for this remediation zone that would eliminate the Site's principal COCs or heavily contaminated media, namely lower vadose zone soils, that contain NAPL or high concentrations of residual contamination.

It should be noted that Alternative SG5b (ERH with VE/Vacuum-Enhanced Groundwater Extraction/P&T/GAC) would require evaluation of the vapor stream, especially with respect to low molecular weight VOCs (vinyl chloride), to indicate whether GAC would provide adequate protection of human health and the environment. If approved for operation, the GAC vapor effluent would require close monitoring of vinyl chloride to assure protectiveness. Likewise, the FTO vapor effluent associated with Alternative SG5a (ERH with VE/Vacuum-Enhanced Groundwater Extraction/P&T/FTO/GAC) would require close monitoring for products of incomplete combustion such as dioxins and furans; although, it is unlikely that an FTO vapor treatment system will emit these chemicals above background levels due to the system's high destruction efficiency.

Alternatives SG2 (ISCO/ISCR/P&T/MNA/UV Oxidation) and SG3 (EISB/P&T/MNA/UV Oxidation) would reduce contaminant concentrations within the Exposition groundwater source area, thereby reducing the potential for COCs to migrate to local domestic production wells. Because this is the primary route of human exposure to COCs through the Exposition groundwater zones, these alternatives would provide adequate protection of human health. However, these alternatives would not be as protective as Alternatives SG5a and SG5b (ERH alternatives) because they would not address the contamination in lower vadose soils, one of the Site's principal threat wastes (source area). Although pump and treat would enhance the distribution of the added substrates, the mechanics of these *in-situ* technologies rely to a great extent on groundwater flow to assist in dispersion. If left untreated, impacted lower vadose soils could act as a continual source of contamination to the Exposition groundwater zones and deeper saturated zones that may be used for local domestic production wells. In addition, because of the elevated concentrations of COCs detected in these groundwater zones (> 20,000 ppb), COCs may not be reduced to the remediation goals. The reduction of COCs to remediation goals would depend on uniform oxidant/reducing agent/substrate delivery throughout the entire source area. Where the processes are effective, it is expected that remediation goals would be achieved. Where the processes are not effective, COCs would continue to pose a risk to potential receptors.

Alternatives SG4a (Vacuum-enhanced Groundwater Extraction/P&T/MNA/UV Oxidation/FTO/GAC) and SG4b (Vacuum-enhanced Groundwater Extraction/P&T/MNA/UV Oxidation/GAC) would provide adequate protection of human health and the environment through reduction of COCs in lower vadose soils and Exposition groundwater within the source area. These alternatives, however, are not as aggressive as the ERH alternatives. As Vacuum-enhanced groundwater extraction may remediate the more coarse-grained lower vadose zone soils, this technology would not likely remediate COCs within the less-permeable fine-grained lithosomes. Therefore, Alternatives SG4a (Vacuum-enhanced Groundwater Extraction/P&T/MNA/UV Oxidation/FTO/GAC) and SG4b (Vacuum-enhanced Groundwater Extraction/P&T/MNA/UV Oxidation/GAC) would not be considered as protective as the ERH alternatives. Nonetheless, the reduction of COCs and the hydraulic control over contaminant mobility provided through groundwater and vapor extraction would ultimately reduce potential pathways to human exposure and the potential for future migration.

4.4.3.2 Compliance with the ARARs/TBCs

The evaluation of the ability of alternatives to comply with ARARs/TBCs included a review of chemical-specific and action-specific ARARs/TBCs that was presented in Section 2.0 of this report. There are no known location-specific ARARs/TBCs for this site. It should be noted that the attainment of ARARs/TBCs in the source area does not necessarily signify that ARARs/TBCs will be attained for the entire lower vadose soil and Exposition groundwater zone as a whole. However, if the source area is eliminated, it is expected that the diluted-phase soil and groundwater plumes will diminish over time.

Alternatives SG5a (ERH with VE/Vacuum-Enhanced Groundwater Extraction/P&T/FTO/GAC) and SG5b (ERH with VE/Vacuum-Enhanced Groundwater Extraction/P&T/GAC) would meet ARARs/TBCs for both *in-situ* soil and groundwater by physically removing contaminants from the subsurface for *ex-situ* treatment. These are the only alternatives assembled for this remediation zone expected to achieve remediation goals in the source area (>10,000 µg/L-contour of the composite Exposition ‘A’ and ‘B’ Zone TCE plume).

However, only Alternative SG5a (ERH with VE/Vacuum-Enhanced Groundwater Extraction/P&T/FTO/GAC) would meet ARARs/TBCs for extracted vapor (in terms of discharge criteria) because this alternative would treat *ex-situ* vapors with an FTO vapor treatment system for the duration of ERH operation (approximately 1 year), during which time, approximately 50% of contamination will be extracted. It is unlikely that the FTO vapor treatment system associated with this alternative will emit products of incomplete combustion, such as dioxins or furans, above background levels due to the system’s highly effective removal efficiency. The FTO would be carefully monitored for the release of these chemicals.

Alternative SG5b (ERH with VE/Vacuum-Enhanced Groundwater Extraction/P&T/GAC), which utilizes GAC to treat extracted vapors, cannot efficiently treat some COCs present within this remediation zone, in particular vinyl chloride. This alternative would require evaluation of the vapor stream to indicate whether GAC would meet ARARs/TBCs or other discharge criteria.

Alternatives SG4a (Vacuum-enhanced Groundwater Extraction/P&T/MNA/UV Oxidation/FTO/GAC) and SG4b (Vacuum-enhanced Groundwater Extraction/P&T/MNA/UV Oxidation/GAC) would likely meet groundwater ARARs through physical removal of groundwater from the subsurface. Because the extracted groundwater exposes lower vadose soils, COCs trapped in soil pores of coarser grained units would be removed as well. This would effectively reduce VOC contamination in these soils, which would likely meet soil remediation goals until concentrations rebound as leaching occurs from finer-grained units, where vacuum-enhanced groundwater extraction would not likely be effective.

Both vacuum-enhanced alternatives would meet ARARs, or discharge criteria, for extracted groundwater through *ex-situ* treatment via UV Ox; however, similar to the ERH alternatives, only Alternative SG4a (Vacuum-enhanced Groundwater Extraction/P&T/MNA/UV Oxidation/FTO/GAC) would meet ARARs/TBCs for extracted vapor (in terms of discharge criteria) because this alternative would treat *ex-situ* vapors with an FTO vapor treatment for the first year of system operation, during which time approximately 50% of contamination will be extracted. It is unlikely that the FTO vapor treatment system associated with this alternative will emit products of incomplete combustion, such as dioxins or furans, above background levels due to the system's highly effective removal efficiency. The FTO would be carefully monitored during its operation for the release of these chemicals.

Alternative SG4b (Vacuum-enhanced Groundwater Extraction/P&T/MNA/UV Oxidation/GAC), which utilizes only GAC to treat extracted vapors, cannot efficiently treat some COCs present within this remediation zone, in particular vinyl chloride at elevated concentrations. This alternative would require evaluation of the vapor stream to indicate whether GAC would meet ARARs/TBCs or other discharge criteria.

The remaining proactive alternatives, Alternatives SG2 (ISCO/ISCR/P&T/MNA/UV Oxidation) and SG3 (EISB/P&T/MNA/UV Oxidation) would likely achieve ARARs for Exposition groundwater quite rapidly, however, with incomplete remediation of soil, the concentrations of COCs in groundwater would likely rebound to some degree and exceed remediation goals in a short period of time. Soil remediation goals would probably not be met, because these alternatives are difficult to implement in the fine-grained, non-saturated soils.

Alternative SG1 (No Action) would not achieve ARARs and TBCs within a reasonable timeframe.

4.4.3.3 Long-Term Effectiveness and Permanence

Alternatives SG5a (ERH with VE/Vacuum-Enhanced Groundwater Extraction/P&T/FTO/GAC) and SG5b (ERH with VE/Vacuum-Enhanced Groundwater Extraction/P&T/GAC) would be expected to provide the highest degree of long-term effectiveness and permanence because they use a technology (ERH) that would be expected to achieve remediation goals for all known COCs and the respective baseline risks within the Lower Vadose Soil and Exposition Groundwater Remediation Zone. Although some uncertainty is associated with the effectiveness of electrical resistance heating at the depths proposed, it has been proven to be effective in several full-scale demonstration projects. It is anticipated that the removal of contaminants within this remediation zone would be permanent and would result in no treatment residuals and no untreated residual risks.

As for *ex-situ* treatment of extracted groundwater and vapor associated with Alternatives SG5a (ERH with VE/Vacuum-Enhanced Groundwater Extraction/P&T/FTO/GAC) and SG5b (ERH with VE/Vacuum-Enhanced Groundwater Extraction/P&T/GAC), UV Oxidation and FTO are proven technologies for permanently destroying all Site COCs without additional disposal requirements. GAC on the other hand requires disposal at an approved landfill/disposal facility. Furthermore, GAC may not effectively remove some COCs from the vapor stream. Both alternatives would require monitoring of the remediation area and *ex-situ* treatment systems to assure effectiveness over the duration of system operation.

Alternatives SG4a (Vacuum-enhanced Groundwater Extraction/P&T/MNA/UV Oxidation/FTO/GAC) and SG4b (Vacuum-enhanced Groundwater Extraction/P&T/MNA/UV Oxidation/GAC) consist of generally conventional and well-proven technologies and are expected to be highly reliable when properly operated and maintained. These alternatives would require a much longer period of time to reduce risks within this remediation zone than Alternatives SG5a and SG5b (about 15 years compared to about 5 years) because the technology (vacuum-enhanced groundwater extraction) that employ Alternatives SG4a and SG4b are less aggressive than those involved in Alternatives SG5a and SG5b (ERH alternatives). In addition, Alternatives SG4a and SG4b would only provide a partial solution to the reduction of COCs in lower vadose soils because this alternative is not effective for reducing contamination within the fine-grained (low-permeability) lithosomes. This is particularly significant within the Exposition ‘B’ Zone, where fine-grained units are more prevalent. The steep cone of depression that resulted during the ‘B’ Zone HVDPE pilot test confirms the limited exposure of contaminated media (fine-grained intervals) to soil vapor extraction. Impacted lower vadose soils not treated by vapor extraction may act as a continual source of contamination to the Exposition groundwater zones and deeper saturated zones through leaching. This alternative would require monitoring of the remediation area to assure effectiveness over the duration of system operation.

The *ex-situ* treatment technologies for extracted groundwater and vapor associated with Alternatives SG4a (Vacuum-enhanced Groundwater Extraction/P&T/MNA/UV Oxidation/FTO/GAC) and SG4b (Vacuum-enhanced Groundwater Extraction/P&T/MNA/UV Oxidation/GAC); namely, UV Oxidation and FTO, are proven technologies for permanently destroying all Site COCs without additional disposal requirements. Alternatively, GAC requires disposal at an approved landfill/disposal facility and may not effectively remove some COCs from the vapor stream. Both alternatives would require monitoring of the remediation area and *ex-situ* treatment systems to assure effectiveness over the duration of system operation.

Alternatives SG2 (ISCO/ISCR/P&T/MNA/UV Oxidation) and SG3 (EISB/P&T/MNA/UV Oxidation) would rely on *in-situ* chemical reactions and biological degradation remedial processes to address the COCs. These alternatives would not address *in-situ* reduction of COCs in lower vadose soils; however, they would involve the potential reduction of COCs and respective baseline risks associated with the Exposition groundwater zones. With appropriate dispersion, distribution, and homogeneity of the treatment (oxidants/reducing agents/substrates), Alternatives SG2 and SG3 would reduce COCs within the Exposition groundwater source area. Where the processes would be effective, little or no residual contamination would remain. However, where the processes are ineffective, these alternatives could result in treatment residuals and/or untreated residual contamination and the magnitude of which poses uncertain risks to potential receptors. For example, with Alternative SG3 (EISB/P&T/MNA/UV Oxidation), PCE and TCE may not complete the reductive dechlorination pathway to ethene with the application of HRC, resulting in the possible generation and accumulation of vinyl chloride, which is more toxic and more mobile than its parent products. Additionally, because of the elevated COC concentrations in these groundwater zones (> 20,000 ppb) and uncertainties associated with uniform substrate distribution and dispersion, residual contamination in these areas could be a remaining source of risk. The effectiveness of these alternatives in mitigating groundwater within the entire Exposition source area would be a function of the density of substrate distribution points and practicality.

For both *in-situ* alternatives, periodic monitoring of groundwater would be required to assess effectiveness and to guide process applications. Several treatments (i.e., substrate injections/additions) and long-term management and monitoring would be required for both of these alternatives.

It should also be noted that some of the COCs at Pemaco are compounds that generally biodegrade anaerobically (e.g., the chlorinated ethenes), some that only degrade aerobically (e.g., petroleum hydrocarbons), and some that are more or less recalcitrant to biodegradation (e.g., 1,4-dioxane). Any enhanced *in-situ* bioremediation program designed for the Site would need to address this and would likely be implemented in several phases.

4.4.3.4 Reduction of Toxicity, Mobility, and Volume (TMV) through Treatment

Alternatives SG5a (ERH with VE/Vacuum-Enhanced Groundwater Extraction/P&T/FTO/GAC) and SG5b (ERH with VE/Vacuum-Enhanced Groundwater Extraction/P&T/GAC) use technologies that physically remove and, through *ex-situ* treatment, destroy COCs so that remediation goals would be achieved in the lower vadose zone and the Exposition groundwater. ERH with VE is the only technology that could effectively reduce the TMV of all COCs within the entire source area of this remediation zone.

As previously discussed, UV Oxidation and FTO are proven technologies for permanently destroying all Site COCs. Thus the TMV of extracted groundwater and vapor, under Alternative SG5a (ERH with VE/Vacuum-Enhanced Groundwater Extraction/P&T/FTO/GAC), would also be reduced. For both ERH alternatives, GAC would reduce the volume and mobility of COCs in the vapor stream. Toxicity reduction via GAC would not occur unless the off-site disposal facility treated the carbon prior to disposal.

Alternatives SG4a (Vacuum-enhanced Groundwater Extraction/P&T/MNA/UV Oxidation/FTO/GAC) and SG4b (Vacuum-enhanced Groundwater Extraction/P&T/MNA/UV Oxidation/GAC) would reduce the TMV of COCs in Exposition groundwater and in the coarse-grained lower vadose soils through physical removal of COCs followed by aboveground treatment. These alternatives would not effectively address COCs trapped within low-permeability (fine-grained) lithosomes of the lower vadose zone such as the ERH alternatives. However, through hydraulic control, the mobility of free product and dissolved phase contaminants within these soils would be reduced. The TMV of extracted groundwater and vapors would be similar to those associated with Alternatives SG5a (ERH with VE/Vacuum-Enhanced Groundwater Extraction/P&T/FTO/GAC) and SG5b (ERH with VE/Vacuum-Enhanced Groundwater Extraction/P&T/GAC), as described above.

Alternatives SG2 (ISCO/ISCR/P&T/MNA/UV Oxidation) and SG3 (EISB/P&T/MNA/UV Oxidation) would not physically remove COCs from the subsurface in the source area like the ERH or vacuum-enhanced groundwater extraction alternatives, nor would they address lower vadose soils. But, through the introduction and uniform distribution of oxidants/reducing agents/substrates, these alternatives would reduce the toxicity and volume of COCs in the Exposition groundwater zones. Pump and treat between the 10 and 1,000 ppb-contours would provide hydraulic control and facilitate dispersion of the oxidizing/reducing agents or substrates. In addition to proper application procedures, pump and treat would also serve as an engineering control to prevent the possible “spreading” of COCs during injection events.

Alternative SG2 (ISCO/ISCR/P&T/MNA/UV Oxidation) uses more aggressive processes that are typically faster and more predictable than Alternative SG3 (EISB/P&T/MNA/UV Oxidation), which would rely on enhancing natural biological processes. While Alternative SG3 (EISB/P&T/MNA/UV Oxidation) enhances these natural processes, they still work at slow, unsustainable rates. Alternative SG3 could also result in the proliferation of PCE and TCE daughter products through incomplete sequential dechlorination (or “stalling” of the dechlorination process at DCE or vinyl chloride). One daughter product, vinyl chloride, is more toxic and more mobile than PCE and TCE. These treatment residuals would pose uncertain risks. In addition, the enhancement of anaerobic biodegradation of chlorinated ethenes is not effective for treating compounds that biodegrade under aerobic conditions (i.e., benzene, toluene). Both of these alternatives have inherent physical limitations of respective substrate delivery in the heterogeneous subsurface, which would likely result in areas with residual contamination after treatment. Because of the aggressive nature and lack of potentially more toxic and more mobile intermediates, Alternative SG2 would be especially effective within the principal source area or 1,000 ppb contour, a.k.a. area of principal threat wastes.

4.4.3.5 Short-Term Effectiveness

This screening criterion is two-fold. One aspect addresses the time until remedial action objectives are met and the other addresses the effects of the alternative during the construction and implementation phase of the alternative.

Alternatives SG5a (ERH with VE/Vacuum-Enhanced Groundwater Extraction/P&T/FTO/GAC) and SG5b (ERH with VE/Vacuum-Enhanced Groundwater Extraction/P&T/GAC) are anticipated to have the greatest short-term effectiveness with respect to meeting remedial action objectives. Lower vadose soil and Exposition groundwater RAOs would be met within approximately 5 years under this alternative. These alternatives necessitate installation of 18 soil vapor extraction wells and 96 electrodes (for ERH), installation of 12 vacuum-enhanced groundwater extraction wells and 15 P&T wells, construction of two aboveground treatment systems (groundwater and vapor), and installation of eight small power delivery stations. Potential risks to workers, the community, and the environment associated with construction (approximately 1 year) and implementation activities of these alternatives include: increased traffic, particulate emissions from vehicles, and high voltage hazards. All of these risks can be mitigated with proper planning and suitable health and safety measures, such as traffic control, worker PPE, air monitoring, and limited access to the aboveground treatment systems/power delivery stations.

Alternatives SG2 (ISCO/ISCR/P&T/MNA/UV Oxidation) and SG3 (EISB/P&T/MNA/UV Oxidation) are very similar with respect to short-term effectiveness, although Alternative SG2 (ISCO/ISCR/P&T/MNA/UV Oxidation) is expected to reach Exposition groundwater RAOs at a faster rate than Alternative SG3 (EISB/P&T/MNA/UV Oxidation) because *In-situ* Chemical Oxidation and *In-situ* Chemical Reduction are more aggressive than Enhanced *In-situ* Bioremediation. Because all of these alternatives rely on *in-situ* destruction and/or degradation remedial processes, it would likely take longer to reach Exposition groundwater

RAOs under these alternatives than Alternatives SG5a and SG5b (ERH alternatives), which involves physical removal of contaminants. Based on monitoring data and dependent on the effectiveness of the processes, it is anticipated that Alternatives SG2 and SG3 would take 1 to 6 years to reach Exposition groundwater RAOs. Baseline risks to the community associated with contaminants in lower vadose soils would remain.

Alternatives SG2 (ISCO/ISCR/P&T/MNA/UV Oxidation) and SG3 (EISB/P&T/MNA/UV Oxidation) each necessitate the installation of 15 P&T wells and 20 monitoring wells within the Exposition ‘A’ and ‘B’ Zones, the coring of 98 injection points (with each injection event to be implemented in an approximate 2-month period), and the construction of an aboveground groundwater treatment system. The only short-term community risks associated with these alternatives would consist of occasional traffic issues related to drilling activities. Additional risks to workers, beyond those associated directly to drilling, consist of the use of strong oxidants associated with Alternative SG4. These risks can be mitigated with proper planning and suitable health and safety measures, such as traffic control, appropriate PPE, and special handling of oxidants by workers.

Alternatives SG4a (Vacuum-enhanced Groundwater Extraction/P&T/MNA/UV Oxidation/FTO/GAC) and SG4b (Vacuum-enhanced Groundwater Extraction/P&T/MNA/UV Oxidation/GAC) are projected to take approximately 2 months to implement/construct and 20 years to achieve Exposition groundwater RAOs. Baseline risks to the community associated with contaminants in lower vadose soils would remain. Short-term risks associated with this alternative are related to the installation of 15 P&T wells and 20 vacuum-enhanced groundwater extraction wells within the Exposition ‘A’ and ‘B’ Zones, the construction of two aboveground treatment systems (groundwater and vapor), and the installation of approximately 1,700 feet of trenching. Short-term risks to the community and environment associated with drilling, construction, and trenching activities include increased traffic, particulate emissions, and potential worker exposure to COCs during remedial and monitoring activities. These risks can be mitigated with proper planning and suitable health and safety measures, such as traffic control, dust suppression, air monitoring, and worker PPE.

4.4.3.6 Implementability

Alternatives SG2 (ISCO/ISCR/P&T/MNA/UV Oxidation) and SG3 (EISB/P&T/MNA/UV Oxidation) would be the simplest alternatives to implement. Both alternatives would require injection well permits or approvals from appropriate state and local agencies prior to implementation. Pilot tests, as described in Sections 3.4.3.2 and 3.4.3.3, would be needed to obtain required design information. The addition of injection points and/or injection events to the assembled alternatives (98 injection points and 2 injection events for Alternative SG2; 98 injection points and 1 injection event for Alternative SG3) could be warranted based on pilot test results and/or system performance and monitoring data. In addition, based on the performance of initial applications, the need for additional injection events would need to be evaluated. Both alternatives would require coordination with the City of Maywood park construction since injection wellheads would be situated within the park boundary. Initial disruption periods are estimated to be about 2 months for either alternative. Personnel, equipment, and materials are generally available for implementation/operation for both alternatives.

Alternatives SG4a (Vacuum-enhanced Groundwater Extraction/P&T/MNA/UV Oxidation/FTO/GAC) and SG4b (Vacuum-enhanced Groundwater Extraction/P&T/MNA/UV

Oxidation/GAC) would be relatively simple to implement, although these alternatives would have more operational requirements than Alternatives SG2 and SG3 because of the additional aboveground vapor treatment system. Overall, these alternatives consist of generally conventional, well proven, and implementable technologies and are expected to be highly reliable when adequately operated and maintained. Personnel, equipment, and materials are readily available for implementation/operation. Coordination with the City of Maywood would be required for well installation activities (20 vacuum-enhanced groundwater extraction wells, 15 P&T wells), which would ideally be installed after final grading activities, but prior to hardscaping and landscaping of the Maywood Riverfront Park. Installation would take approximately 2 months. The aboveground treatment systems associated with Alternatives SG4a and SG4b would be coordinated with the City of Maywood and could be situated in the southeast corner of the park. Modifications to the assembled alternative could be warranted based on system performance/monitoring data (e.g., additional extraction wells). Groundwater monitoring would be necessary to assess remediation effectiveness and contaminant plume status. Discharge permits or disposal facility acceptance for treated groundwater would generally be required.

Alternatives SG5a (ERH with VE/Vacuum-Enhanced Groundwater Extraction/P&T/FTO/GAC) and SG5b (ERH with VE/Vacuum-Enhanced Groundwater Extraction/P&T/GAC) are the most complex alternatives to install/construct and, during implementation, to operate. Although ERH with VE is no longer considered an innovative technology, it is a relatively new technology that requires sophisticated equipment and skilled technical personnel. As such, relatively few vendors offer ERH with VE and personnel, equipment, and materials have limited availability. A pilot test would be needed to establish suitability of the method at the site and to obtain additional design information, as described in Section 3.4.3.6. System modifications to the suggested 96 electrodes, 18 soil vapor extraction wells, 12 vacuum-enhanced groundwater extraction wells, and 15 P&T wells could be warranted based on performance and monitoring data. A large portion of the Maywood Riverfront Park would be disrupted for approximately 1-year. The partial park closure would need to be coordinated in cooperation with the City of Maywood.

4.4.3.7 Estimated Cost

A summary of estimated costs for each of the lower vadose zone soils and Exposition groundwater remediation zone alternatives is presented in Table 4.2. A more detailed cost estimate for each alternative associated with this remediation zone is provided in Appendix I.

The cost estimates summarized in Table 4.2 and detailed in Appendix I have been developed strictly for comparing the alternatives. The final costs of the treatment alternatives will depend on competitive bids, actual market conditions, actual site conditions, final project scope, and implementation schedules. Because of these factors and those unforeseen, project feasibility and requirements must be reviewed carefully to adequately address the decisions related to project funding.

The cost estimates are “order-of-magnitude” estimates having an intended accuracy range of +50% to –30%. They are not intended to limit the flexibility in the selection of the remedial design but to provide a basis for evaluating cost in light of the other modifying criteria. The specific details of the remedial actions and cost estimates would be refined once all screening criteria are considered in preparation of the ROD.

Alternative SG3 (EISB/P&T/MNA/UV Oxidation) has the lowest total present worth cost (approximately $4.8 million) with the exception of Alternative SG1 (No Action).

The second least expensive alternatives are Alternative SG4b (Vacuum-enhanced Groundwater Extraction/P&T/MNA/UV Oxidation/GAC) and Alternative SG2 (ISCO/ISCR/P&T/MNA/UV Oxidation). They have similar total present worth costs of approximately $5.4 million. Alternative SG2 (ISCO/ISCR/P&T/MNA/UV Oxidation) uses a technology that is identical in application to Alternative SG3, but is more expensive mainly because of the cost of reagents. Therefore, Alternative SG2 is not considered to be as good a value as Alternative SG3.

Alternative SG4a (Vacuum-enhanced Groundwater Extraction/P&T/MNA/UV Oxidation/FTO/GAC) provides the fourth lowest total present worth cost at approximately $6.1 million. Comparatively, Alternative SG4a uses a technology that is identical in application to Alternative SG4b (Vacuum-enhanced Groundwater Extraction/P&T/MNA/UV Oxidation/GAC), but is more expensive due to the addition of an FTO vapor treatment system for use during the first year of system operation. As the majority of COCs will be extracted during the first year and some COCs within this remediation zone, in particular vinyl chloride, cannot be treated by GAC at elevated concentrations, the FTO treatment system associated with Alternative SG4a is considered to be a good value.

Alternatives SG5a (ERH with VE/Vacuum-Enhanced Groundwater Extraction/P&T/UV Ox/FTO/GAC) and SG5b (ERH with VE/Vacuum-Enhanced Groundwater Extraction/P&T/UV Ox/GAC) provide the most expensive alternatives with a total present worth of approximately $8.8 to 8.9 million, respectively. These alternatives are estimated to be the most effective and expeditious of all the alternatives. The cost effectiveness of this alternative may be considered good based on the estimated high effectiveness over a short period of time. However, they are significantly more expensive than the other alternatives - which are estimated to be less effective and take a longer period of time.

4.4.3.8 State Acceptance

To be addressed in the ROD.

4.4.3.9 Community Acceptance

To be addressed in the ROD.

5.0 REFERENCES

Biren, Paul (Biren, August 1992), Los Angeles County Fire Department, Hazardous Waste Control Program, *Statement of Probable Cause*, August 10, 1992.

Bradford, G.R., Chang, A.C., Page, A.L., Bakhtar, D., Frampton, J.A., and Wright, H., (Bradford, et al., 1996), Kearney Foundation of Soil Science - University of California, *Background Concentrations of Trace and Major Elements in California Soils*, March 1996.

Ecology & Environment (E&E, 1998a), *Pemaco Maywood Expanded Site Investigation*, March 1998.

Ecology & Environment (E&E, 1998b), *Subsurface Investigation Pemaco Site Maywood, California*, March 1998.

Ecology & Environment (E&E, 1999), *Pemaco Removal Site Final Report*, May 1999.

Hocking, G., Wells, S.L. and R.I. Ospina (May 2000). Deep Reactive Barriers for Remediation of VOCs and Heavy Metals. 2nd Int. Conf. On Remediation of Chlorinated and Recalcitrant Compounds, Monterey CA.

Levine-Fricke (LFR, 2001), *Soil, Soil Gas, and Groundwater Evaluation, Former W.W. Henry Property, 5920 Alamo Avenue, Maywood, California*, 6 July 2001.

State of California Dept. of Water Resources (State of California, 1961), *Bulletin No. 104: Planned Utilization of the Groundwater Basins of the Coastal Plain of Los Angeles County*, Appendix A, Ground Water Geology, 1961.

T N & Associates, Inc. (TN&A, 2000), *Draft Summary of Groundwater and SVE System Sampling Events,* October 2000.

T N & Associates, Inc. (TN&A, 2002a), *Draft Remedial Investigation, Pemaco Superfund Site 5050 E. Slauson Avenue*, Maywood, California, 2002.

T N & Associates, Inc. (TN&A, 2002b), *Draft Technical Memorandum, Results of Groundwater Monitoring Activities, May 2001 through April 2002, Pemaco Superfund Site 5050 E. Slauson Avenue*, Maywood, California, 2002.

T N & Associates, Inc. (TN&A, 2002c), *Environmental Site Assessment, Los Angeles Junction Railway Property*, Maywood, California, 2002.

T N & Associates, Inc. (TN&A, 2002d), *Health Risk Assessment, Maywood Riverfront Park, Maywood, California*, July 19, 2002.

Puls, R.W., R. Wilkin, C. Paul, F. Beck, P. Clark and M. McNeil (2002). Six Years of Intensive Monitoring of the 1st PRB to Treat a Mixed Waste Plume: USCG Site in Elizabeth City, NC, RTDF PRB Action Team Meeting, Washington D.C. Nov. 7-6.

United States Army Corps of Engineers, Omaha District (USACE 1997), *General Chemistry Supplement to the Scope of Services for Studies*, December 1997.

United States Environmental Protection Agency (USEPA 1983), *Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans,* February 1983.

United States Environmental Protection Agency (USEPA 1983b), *Methods for Chemical Analysis of Water and Wastes,* March 1983.

United States Environmental Protection Agency (USEPA 1991*), Office of Emergency and Remedial Response (OERR) Directive 9345.3-02*, May 1991.

United States Environmental Protection Agency (USEPA 1986), *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods* (USEPA SW-846, Third Edition, and its first and second update), November 1986.

United States Environmental Protection Agency (USEPA 1993), *Data Quality Objectives Process for Superfund, Interim Final Guidance,* September 1993.

United States Environmental Protection Agency (USEPA 1994a), *USEPA Contract Program National Functional Guidelines for Organic Data Review* (USEPA-540/R-94/012), February 1994.

United States Environmental Protection Agency (USEPA 1994b), *Contract Laboratory Program National Guidelines for Inorganic Data Review* (USEPA-540/R-94/013), February 1994.

United States Environmental Protection Agency (USEPA 1994), *USEPA Requirements for Quality Assurance Project Plans for Environmental Data Operations, Interim final* (USEPA QA/R-5), August 1994.

United States Environmental Protection Agency (USEPA 2000a), *Drinking Water Standards and Health Advisories,* (USEPA-822-B-00-001), Summer 2000.

United States Environmental Protection Agency (USEPA 2000b), *EPA Region 9: Preliminary Remediation Goals (PRGs)*, http://www.epa.gov/region09/waste/sfnd/prg/, October 2000.

United States Environmental Protection Agency (USEPA 2000c), *User's Guide for the Johnson and Ettinger (1991) Model for Subsurface Vapor Intrusion into Buildings (Revised)*.